Annual Scientific Reports of the Indian Agricultural Research Institute

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SCIENTIFIC REPORTS

OF THE

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PREFACE

The Indian Agricultural Research Institute, now located at New Delhi and popularly known as the I.A.R.I. or "Pusa Institute", was originally established by the Government of India in 1905 at Pusa, a village in North Bihar. The establishment of the Institute was greatly helped by the benefaction of an American philanthropist, Mr. Henry Phipps, after whom the main laboratory building at Pusa, and later the laboratories of the Division of Soil Science and Agricultural Chemistry at New Delhi, have been named. The Institute was first named Agricultural Research Institute and it was later renamed Imperial Institute of Agricultural Research, Imperial Agricultural Research Institute and, finally, Indian Agricultural Research Institute.

The establishment of the Institute, in fact, marked the beginning of agricultural research on organised scientific lines in India. During the early years at Pusa, pioneering work was done at this Institute by eminent scientists, like J. W. Leather in Agricultural Chemistry, Edwin J. Butler in Mycology and Plant Pathology, H. Maxwell Lefroy and T. Banbrigge Fletcher in Entomology and Albert Howard in the breeding of improved varieties of crop plants, including the famous 'Pusa' wheats. In subsequent years, notable work was done in sugarcane breeding by T. S. Venkataraman at the Sugarcane Breeding Substation, Coimbatore (South India), which until recently formed a part of this Institute. The 'Co' varieties of sugarcane bred by him are known all over the world. The most notable recent achievement of the Institute has been the production of a series of improved, disease-resistant wheat varieties (now well known as the New Pusa or "N.P." wheats). In the course of the development of this Institute, the expansion of research in some crops resulted in the establishment of new institutes. The foundations of research in cotton, silk, lac, tobacco, potato and sugarcane in India were first laid by this Institute which nursed the research activities in these subjects till they were later taken over, each by a separate research organisation, such as the Bhagalpur Silk Institute, Bhagalpur (Bihar), the Indian Lac Research Institute, Ranchi (Bihar), the Central Tobacco Research Institute, Rajamundry (Andhra Pradesh), the Central Potato Research Institute, Simla (Punjab), and the Sugarcane Breeding Institute, Coimbatore (Madras State). The organisation of Research in cotton was taken over by the Indian Central Cotton Committee, Bombay, in 1921.

The great earthquake of Bihar in 1934 caused considerable damage to the Institute's buildings and properties at Pusa. It was then decided to shift the Institute to its present site in New Delhi. The transfer was completed in 1936. Here the Institute stands to-day, a well laid out, 1100-acre colony about 4 miles west of the New Delhi Railway Station. The latitude is 28.4°N, the longitude 77.1°E, and elevation above mean sea level 750 ft. The maximum and the minimum temperatures during the year range between 52.6°F and 116°F and 30.0°F and 91.8°F, respectively, and the average annual rainfall is about 23 inches, of which about 2-3 inches are received during the winter months. The soil type is predominantly light loam.

Since 1945, and especially after Independence, the Institute expanded considerably its facilities of expert staff, buildings, equipment and experimental fields. It is to-day regarded as the premier institute in which there exist the best facilities that are available in the country for the conducting of basic and applied research in almost all the

major disciplines of agricultural sciences, and for imparting post-graduate training of the highest order in these disciplines. The Institute is under the direct administrative control of the Union Ministry of Food and Agriculture and works in close co-operation with the Indian Council of Agricultural Research which is concerned with promoting, co-ordinating and financing research schemes on agriculture and animal husbandry in India.

The five Sections of the Institute which were in existence at the time of the transfer from Pusa, have grown into the full-fledged Divisions of Agronomy, Botany, Entomology, Mycology and Plant Pathology, and Soil Science and Agricultural Chemistry. The Division of Agricultural Engineering was established in 1945. A section of Horticulture was started in the Division of Botany in 1954, and in 1957 it became a separate Division of Horticulture. Similarly, the Section of Agricultural Extension in the Agronomy Division has become a full-fledged Division of Agricultural Extension since October, 1960. Thus the Institute has eight major Divisions, each under a Head of the Division. The Section of Agricultural Economics, now located in the Division of Agronomy, is also soon expected to become a full-fledged Division under the Institute. In 1958, the All-India Soil and Land Use Survey started functioning as a separate unit of the Institute, under the charge of the Chief Soil Survey Officer. The Institute has 11 substations located all over the country, excluding the 24 regional soil testing laboratories so far established and the centres and sub-centres set up in the country under the Co-ordinated Maize Breeding Scheme, the work of which the Institute helps to co-ordinate on behalf of the Indian Council of Agricultural Research. The over-all charge of the Institute vests, since 1945, in a full time Director, who is assisted by a part-time Joint Director and the Registrar and other administrative staff of the Directorate.

Each of the Divisions, except at the moment the Divisions of Horticulture and Agricultural Extension, is housed in separate buildings, each one complete with laboratories, glass-houses, workshops and research and auxiliary staff. The I.A.R.I. Library, possessing about 1,52,000 technical books and 1,253 scientific periodicals, is considered to be the biggest agricultural library in India. The Division of Agronomy has bred, and maintained a Sahiwal herd of milch cows which is regarded as one of the most consistent performing herds of the world. In the Division of Botany, extensive living collections of crop plants and related species have been built up with the assistance of the All-India Plant Introduction and Exploration Organisation located in that Division. The programme of mutation research under way in that Division, has received a great fillip with the inauguration of 'GAMMA GARDEN' with its powerful 200 curie source of radioactive cobalt-60, in August, 1960. A valuable National Pusa Insect Collection is housed in the Division of Entomology, and the Mycological Herbarium (*Herbarium Cryptogamae Indiae Orientalis*) and the Indian Type Culture Collection of fungi and bacteria, in the Division of Mycology and Plant Pathology. The Radio-tracer laboratory is attached with the Division of Soil Science and Agricultural Chemistry as also the Cartographic Laboratory and the co-ordinating centre of the All-India chain of Soil Testing Laboratories.

Besides the regular programme of research, the various Divisions of the Institute operate a number of research projects financed either by the Ministry of Food and Agriculture itself or by bodies like the Indian Council of Agricultural Research and

various Commodity Committees. These include, besides several others, a project on All-India trials on Fertilizers and Land Use and a Co-ordinated Maize Breeding Scheme dealing with research on hybrid maize. In recent years, the Institute has been entrusted, on an increasing scale, with the co-ordination of research projects on regional basis and in several such projects it is receiving the excellent co-operation of foreign organisations like the Indo-U.S. Technical Co-operation Mission and the Rockefeller Foundation.

In an effort to carry the fruits of research to the farmers, the Institute is carrying out, since 1950, extension work in a block of villages in Delhi State under its Delhi Intensive Cultivation Scheme and now an entire extension block in Delhi State, namely the Kanjhawala Block, is also entrusted to the Institute for carrying out extension work.

Post-graduate training constitutes an important part of the Institute's activities. Besides short-term and refresher courses, regular 2-year courses in the major disciplines of agricultural science, leading to the award of the Diploma of Associateship of the Institute, have been given at the Institute since 1923. This system of post-graduate training was re-organised in 1958, when the Post-Graduate School was set up and the Institute was accorded the status of a University for organising courses of instruction leading to the award of the M.Sc. and Ph.D. degrees in Agricultural Sciences. The courses are now given on the lines of the course credit system in vogue in the American Universities with such modifications as are deemed desirable to suit conditions in India. The post-graduate students' hostels provide residential accommodation to about 300 M.Sc. and Ph. D. students. The Institute has received the generous co-operation of the Rockefeller Foundation in this educational project.

The Institute is annually visited by numerous visitors, dignitories, administrators, scientists and farmers from within the country as well as from abroad. They have been appreciative of the research facilities obtaining here and also of the efforts made by the Institute in the service of Indian agriculture.

I. REPORT OF THE DIRECTOR

1. INTRODUCTORY

The scientific reports of the Institute have so far been based on the crop-year ending 30th June and it is now proposed to issue the future reports for the calendar year with effect from January, 1961. The present report for the period 1st July, 1960 to 31st December, 1960 is being issued to bridge over the gap.

Further progress was made during the period under report in the activities of the Institute in the field of research, post-graduate education and extension. A number of new projects were formulated, as working papers, for ultimate inclusion in the Third Five Year Plan, of which those accepted in principle by the Government of India include the proposal to set up at the Institute a phytotron—an artificial climate-house for experimental work—and a Division of Microbiology, as also a Section of Nematology. The work on the Gamma Garden was completed and the 'Garden' was formally inaugurated on 26-8-60 by Shri S. K. Patil, Union Minister for Food and Agriculture. This unique facility for field irradiation with gamma rays, which will be made available to all biological scientists in the country, is now ready for use. Plans were finalised for the construction of the building, which has made considerable headway, for the Cereal Research Laboratory, for which milling, baking and cereal testing equipment has been provided by the Indo-U.S. Technical Co-operation Mission. The research work on hybrid maize reached an advanced stage and four of the outstanding flint-type double-cross hybrids developed at the Institute under the Co-ordinated Maize Breeding Scheme, in which the Rockefeller Foundation is actively participating, have been released for seed production on a large scale.

The Post-Graduate School, in the organisation and operation of which the Rockefeller Foundation have given considerable assistance, continued to make steady progress during the Second Year of its inauguration. Dr. R. W. Cummings, Field Director of the Foundation in India, very kindly continued to act as the Dean of the P. G. School, in an honorary capacity, pending official recruitment to that post till the 10th November, 1960, when Dr. A. B. Joshi was appointed as the Dean.

The fifth in the series of research reports being issued by the Institute for the benefit of research workers in the country, was issued during the period under report. It deals with an account of the prevalence of physiologic races of wheat and barley rusts in India during 1952-57.

With the appointment of Shri A. R. Khan as the Head of the Division of Agricultural Extension in October, 1960, the Section of Agricultural Extension of Agronomy Division became a full-fledged Division and the Scheme for the post-graduate training in Agricultural Extension which was so far managed by the Division of Agronomy, was transferred alongwith the staff to the new Division of Agricultural Extension. The technical control of the Intensive Cultivation Scheme, and the Key Village Scheme was also transferred to the Extension Division.

The administration of the Institute has been considerably strengthened by the appointment of Shri Vas Dev as Registrar in the senior scale and it is also proposed to appoint a Deputy Registrar to assist him.

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2. SUMMARY OF MAIN RESULTS OF RESEARCH

Agronomy

1. *Soil Fertility*:

In the investigations on the role of legumes in soil fertility building, it has been found that the application of phosphate to *guar* (*Cyamopsis tetragonoloba*), a kharif legume, under rainfed conditions increased the yield significantly, thus indicating the possibility of increased crop production under *barani* conditions.

At Pusa (Bihar), organic manures, farm-yard-manure and rape cake at 40 lbs N per acre increased the yield of maize significantly over artificial fertilizers supplying equivalent N. Application of N and P to cotton, either through broadcast or foliar spray, showed little effect on yield. Encouraging response due to P was, however, obtained when the fertilizer was placed at 3-inch depth directly under the seed in a single band.

A dose of 160 lb N and 60 days interval of cutting was found to be optimum for Napier grass under irrigated condition.

In a spacing-*cum*-fertility trial with *jowar* (*Sorghum vulgare*), spacing of rows 18 inches apart was found to be more conducive to yield than a spacing of 30 inches. In the case of maize, however, the yield decreased as the row-spacing was increased from 24 inches to 30 inches.

2. *Irrigation Investigations*:

Potato crop when irrigated at intervals of 7 to 12 days during November, December and January yielded about 65 mds. of potato per acre more than the crop irrigated at 14-20 days' interval. In the case of cotton, pre-monsoon irrigation did not increase the yield this year, probably owing to early break of rains in June.

3. *Weed Control*:

Application of 'Simazine' at 2 lb plus 2,4-D at 12 oz. per acre was found to be as effective as 4 times hand-weeding, judged from the yield of maize and the control of weeds obtained in the experimental plot.

4. *All-India Co-ordinated Scheme of Fertilizer Trials*:

Under the All-India Fertilizer Use Project, 7,410 Simple Experiments were conducted in 135 districts on cultivators' fields. The Complex Fertilizer Experiments were conducted at 34 centres under the Model Agronomic Experiments Scheme.

5. *Agricultural Economics*:

Investigations carried out in the Agricultural Economics Section showed that with an increase in the size of holdings, the strength of live-stock also increases and the labour cost per animal tends to go down. Human and bullock-labour were more intensively used in smaller holdings in contrast to holdings of larger size. Consequently, cost of cultivation of crops per acre declined with increase in the size of holdings.

Agricultural Engineering

1. *Cultivator*-cum-*Seed Drill* :

A field cultivator-*cum*-seed drill has been developed from a device received from T.C.M., Greece, and has shown considerable promise of a cheap and efficient bullock-drawn cultivator-*cum*-seeding unit.

2. *Inter-cultural Implements*:

The hand hoe developed in the Division which enables the operator to do hoeing and weeding in the standing posture, reported upon earlier, has given satisfactory field performance in further trials and is being patented.

3. *Hand Dibbler with seed metering mechanism*:

A hand dibbler has been fitted with a seed metering mechanism developed in the Division. Preliminary tests conducted have given very encouraging results and the seed metering mechanism is being patented. The device can be incorporated with any planter or seeder where precision metering and placement of seed are essential.

4. *Disc Harrow*:

The bullock drawn off-set disc harrow developed last year has shown good performance in the field.

5. *Tile Drainage for water-logging problem at IARI*:

Piezometer tubes fitted after drilling holes through them have given better discharge and the data collected so far clearly show that the underground tile system for drainage of excessive sub-soil water is working efficiently and effectively.

Agricultural Extension

1. *Intensive Cultivation Scheme* :

The extension work in the 19 villages of Delhi State as also in the Kanjhawala Block was continued. Different methods of extension were being experimented upon and evaluated by the extension staff and post-graduate students.

(a) *Result Demonstrations.*—During the period under report, 115 plots to demonstrate the efficacy of fertilizers, improved seed, improved implements and better cultural practices were laid out.

(b) *Wheat Varieties.*—The two new wheat varieties—N.P. 823 and 824—reported to be higher yielding than N.P. 718, the previous improved variety given out for general cultivation in these Intensive Cultivation Scheme villages, are being recommended for cultivation and the cultivators appear to appreciate the superiority of these varieties.

(c) *Introduction of Berseem.—Berseem* which has been introduced as a new fodder crop in the Intensive Cultivation Scheme villages is gaining popularity and 17 more cultivators have taken it up this season.

(d) *Supply of Improved Seed to the States.*—This useful activity of the Scheme was continued and about 373,240 kg. of wheat (N.P. 718) seed and 29,859 kg. of gram (N.P. 58) seed were supplied to the State Departments of Agriculture of West Bengal, Orissa and Kutch.

2. *Key Village Scheme*:

The work of the Key Village Scheme was continued during the period and efforts were being made to popularize artificial insemination of cattle among the farmers. Regular supplies of semen were also being made to the Veterinary Department, Delhi State.

The 8 Cow lung gas plants installed in the Intensive Cultivation Scheme villages are working satisfactorily and there is a demand for two more similar gas plants on 50:50 basis, for which the arrangements are being made.

Botany

1. *Plant Breeding and Genetics*:

(a) *Maize.*—Performance tests were carried out on 540 single crosses, the production of which involved 45 elite inbred lines from diverse Indian and foreign sources. From the results of these tests, a number of outstanding double crosses have been predicted and finally selected for large scale production and extensive testing.

(b) *Bajra.*—The outstanding performance of the type, Improved Ghana, the original material of which was introduced by this Institute from Ghana, was confirmed for the third year in succession. The Improved Ghana gave a yield of 741 kg. per acre, as compared to 605 kg. by the Punjab variety, T-55, and is now ready for trials in the cultivators' fields.

(c) *Vegetables.*—Further reports have been received from all over the country regarding the excellent performance of the *bhindi* variety, *Pusa Sawani,* in respect of yield and freedom from the yellow-vein-mosaic virus disease. "Sylvia", a Swedish pea variety with sweet and edible pods, was released for distribution.

(d) *Grasses.*—In a small-scale test of performance, the interspecific hybrid between cultivated *bajra* (*Pennisetum typhoides*) and Elephant grass (*P. purpureum*) has given outstandingly higher forage yield than Elephant grass; and another hybrid between indigenous *anjan* grass (*Cenchrus ciliare*) and an exotic strain of *Pennisetum ciliare* has far out-yielded the indigenous *anjan* grass. The hybrids will be given extensive field tests.

2. *Cytology and Cytogenetics*:

(a) *Jute.*—An interesting range of character combination was observed in the F_2 and back-cross progeny of the interspecific hybrid, *Corchorus olitorius* x *C. capsularis.* The hybrid, normally not achievable, was secured earlier by adopting a reciprocal grafting-*cum*-pollen irradiation technique.

(b) *Berseem.*—Some promising strains isolated from colchicine-induced tetraploids of *berseem* (*Trifolium alexandrinum*) have now reached the stage of large scale testing

3. *Crop Physiology*:

In a comparative study of two wheat varieties, Pb. C. 281 and N. P. 720, grown in pot culture under normal water supply and intermittent drought, a correlation was observed between 1000-grain weight and sugar content of stem soon after dehiscence, indicating thereby that grain development may partly be determined by the level of sugar accumulation in the stem.

4. *Plant Introduction*:

One thousand one hundred and twelve samples of seed and planting material were introduced from abroad and 803 samples were collected from within the country during the period under report. These include 500 genetic stocks of wheat, and 300 of barley, obtained from the U.S.A., Israel and East Germany; sweet potato varieties, reported to be resistant to weevil attack, from the Fiji Islands; wheat varieties, tetraploid rye and many other varieties, which may be suitable for high altitude areas in Himachal Pradesh, Kashmir and Ladakh, from Switzerland, East Germany and Sweden; and high tannin yielding strains of *Rumex hymenosepalus*.

Among the materials introduced earlier and evaluated, mention may be made of a very early maturing, fodder-*cum*-grass type of cowpeas (E.C. 4211); a white-grained high yielding chenopod variety belonging to *Chenopodium quinoa* from South America; and shoot-borer resistant species, *Amaranthus montegazzianus*, of grain amaranth.

Entomology

1. *Taxonomy*:

Three new genera of mud wasps (Sphecoidea) were recorded for the first time from India. Keys for the separation of these genera and identification of the various species within each genus were drawn up.

2. *Insect Parasitology* :

In the biological control of insect pests studies, 12 primary and secondary hymenopterous parasites of various insects were recorded of which three proved to be new genera for India. In addition, a new species of predatory mite has been described. A phytophagous mite has been found to be associated with mango malformation, a serious disease of this important fruit tree.

Investigations on the effect of nutrition on the fecundity of an egg-larval parasite (*Chelonus rufus* Lyle) of *Erias* spp. and *Laphygma exigua* (Hbn.) showed that maximum egg production was obtained when the female parasites were fed on honey. As regards the effect of temperature, it was observed that maximum egg production was obtained at 30 C.

3. *Ecology and Toxicology* :

Studies on the chemical control schedule of pests of maize crop showed that spraying the crop with Parathion and D.D.T. mixture was most effective and treated plots gave twice the yield of grain as compared to the 'Control'.

In the experiments on the phyto-toxic effects of insecticides, maize seedlings raised from seed treated with lindane @ 20 lb/100 lb of seed (*i.e.* about 2.5 lb lindane per acre for grain crop) was found to be toxic to the first stage larvae of maize stem borer up to 20 days after sowing.

BHC and DDT spray residues were found to persist on tomatoes and peas even upto 14 days after treatment. Wheat stored in gunny bags was found to get contaminated with BHC when the bags were dusted with 5% BHC Dust.

4. *Insect Physiology* :

Nutritional studies on the red cotton bug (*Dysdercus* sp.), a serious pest of cotton, have shown that certain ether, alcohol, chloroform or acetone-soluble substances contained in the cotton seed are essential for the development of the bug indicating thereby the crop-pest relationship.

Horticulture

1. *Pomology* :

In vegetative propagation studies with sweet lime, it was found that a mixture of Indoleacetic acid (IAA) and Indolebutyric acid (IBA), at 1500 ppm, gave the highest percentage of survival in hard-wood cuttings. In the case of *guava,* the Sphagnum moss medium induced early rooting in air-layers but gave lower rooting percentage as compared to vermiculite. Furthermore, the month of April was found to be the best time for shield-budding of *Chittidar* (freckled) variety of *guava* while March budding gave better results in the case of *Safeda* (white) variety. The treatment of *guava* scion with IBA (1 ppm) improved percentage of bud-take, and IBA 350 ppm and 25 ppm proved helpful in rooting of *guava* and *phalsa* air-layers, respectively.

Studies in the pre-harvest drop of fruit in sweet orange showed that spraying with 2,4,5-Trichlorophenoxyacetic acid (30 ppm) and 2,4-Dichlorophenoxyacetic acid (15 ppm) proved effective in reducing the pre-harvest drop in *Mosambi* and Pineapple varieties, respectively. Maturity of fruit was accelerated with Maleic hydrazide (2500 ppm) while 2,4-D and 2,4,5-T delayed the fruit ripening.

2. *Vegetables* :

In the hybrid-vigour studies with 7 commercial varieties of tomato and their 13 F_1 crosses it was observed that all the hybrids gave higher early yield as compared to the parents; the hybrid Pusa Ruby x Best-of-All proved to be the best, out-yielding the better parent (Pusa Ruby) by about 50%.

Investigations on the application of plant growth regulator sprays to vegetable crops confirmed that maleic hydrazide (MH), alpha-naphthaleneacetic acid (NAA), indoleacetic acid (IAA) and gibberellic acid (GA) can induce earlier and greater number of female flowers in cucumber thus indicating the possibility of modification of sex expression and sex ratio in cucumber by chemical sprays. GA at 10 ppm induced giant ovaries which developed into parthenocarpic fruit.

3. *Fruit and Vegetable Preservation* :

Of the 14 varieties of peas tested, 4 varieties, namely, Bonneville, Early Giant, Yates Early Crop and Duke of Albany were found to be suitable for canning.

Ambri variety of apples gave the best apple preserve. The oxidative browning in the peeled fruit could be prevented by steeping in 25% salt solution containing 400 ppm of SO_2.

In the experiment on drying and dehydration of vegetables, of the 7 varieties of peas tested, 4 varieties (NP 29, T 19, Bonneville and Early Giant) gave satisfactory dehydrated products.

4. *Floriculture* :

One hundred and forty-eight rose varieties consisting of HT class, Floribundas, Miniature types and Climbing roses were introduced from U. K. and Germany, thus raising the number of varieties in the National Rose Collection to 756.

Mycology and Plant Pathology

1. *Wheat Rusts* :

Exhaustive studies on the physiologic races of wheat rusts revealed the presence of a new race (Race 16) of brown rust in the country. Of the existing races, race 40 of black rust and 162 of brown rust were found to be most prevalent.

In the varietal resistance tests, five wheat cultures proved to be resistant to brown rust and 17 wheat varieties to black rust.

2. *Bunt of Wheat* :

In the cultural studies with the Karnal bunt fungus it was observed that the addition of thiamine to the medium resulted in excellent growth.

In the host-range studies with Hill bunt (*Tilletia foetida*), out of the 22 wild grasses inoculated, infection could be traced only in *Lolium perenne*.

3. *Sugarcane Rust* :

Indications of the existence of physiologic races of the rust have been obtained. In the collateral host studies, *Erianthus fulvus* rust was found to infect sugarcane (Co.S. 510) producing resistant type of reaction, but failed to infect *Erianthus munja*.

4. *Downy Mildew of Maize* :

Kans grass (*Saccharum spontaneum*) has been established to be the collateral host of the downy mildew of maize, indicating thereby the means of perpetuation of the disease in the absence of the resting oospore stage.

5. *Virus Diseases* :

Mosaic diseases of mulberry, *guar* and *Amorphophallus campanulatus* and "mottle" disease of sweet potatoes were established to be of virus origin. Sterility disease of pigeonpea was transmitted by an eriophyid mite; and Mango Malformation has been reproduced with eriophyid mites collected both from diseased and healthy plants. The Virus causing chlorosis of *Jowar* has been transmitted to sugarcane, Elephant grass (thick variety), *Canna indica* and *Erianthus* sp. through its jassid vector, which carries the virus in a persistent manner.

An antiserum was prepared for the bottle-gourd mosaic virus and its antigenicity was established by the precipitin test.

6. Physiology of Fungi :

The Pathogenicity of the biochemical mutant of *Colletotrichum falcatum* deficient in *p*-aminobenzoic acid, which is practically non-pathogenic on sugarcane, could be increased by supplying the vitamin to the host. It has been demonstrated that the growth factors required by the *C. falcatum* isolate 78 for its growth are normally synthesised by the isolate 244.

A high antibiotic-yielding strain of *Bacillus subtilis* has been obtained by irradiation with Gamma rays.

7. Fungicides :

Of the three new compounds (developed at the I.A.R.I.) tested for their comparative fungicidal properties, Cyml mercury acetate proved to be most efficacious, and was effective even at 1 ppm concentration.

8. Systematic Mycology :

Three new species and 9 new host-records for India were reported in the studies on the genus *Cercospora,* including *Cercospora sorghi* on maize. Amongst the entomogenous fungi, *Aspergillus parasiticus* was recorded on mosquitoes and *Sporotrichum* sp. on aphids. Critical studies have also revealed some noteworthy Ascomycetes on oak and coffee; Basidiomycetes on Fern, *Artemisia* and *Flacourtia;* as also several new records of Fungi Imperfecti. Of the 130 fungal specimens collected locally in or around Delhi, 4 proved to be new records.

Soil Science and Agricultural Chemistry

1. Manures and Fertilizers :

Preliminary results obtained in pot-experiments indicate that the manurial value of Cowdung Gas Plant slurry compares favourably with that of Farm-Yard-Manure on equal N basis.

2. Physical Chemistry :

Sufficiency of Potassium in the soil for plant growth is being estimated by the study of thermodynamics of potassium availability. The equilibrium potassium absorption ratio of 0.752×10^{-2} was found to indicate potassium sufficiency in the soil for paddy. The corresponding figure for wheat was found to be 0.308×10^{-2}. These values tally with the potassium absorption ratio of healthy plants of these crops.

3. Organic Chemistry :

A new technique for the rapid estimation of pyrethrins in the pyrethrum flowers, based on determining the proportions of un-saponifiables and their apparent conjugated unsaturation, has been worked out. Pyrethrin-I is estimated by determining the proportions of apparent conjugated unsaturation of the petrol-soluble acids; and pyrethrin-II by the proportions of apparent conjugated unsaturation of the petrol-insoluble, water-soluble acids.

4. *Biochemistry* :

In the studies on the biological value of wheat proteins, the protein efficiency ratio of a few NP wheats, fed for four weeks to weaning rats at 8% protein level, varied from 1.58 to 2.04.

Investigations in the protein synthesis by *Aspergillus niger* showed that under copper deficiency the synthesis of proteins by *A. niger*, grown in sucrose-nitrate-mineral medium, was greatly retarded.

5. *Physics* :

Absorption spectroscopic studies, both in the visible and infra-red regions, of *Cucumis* virus 2C indicated the possibility of using the intensity of the bands corresponding to nucleic acid proteins present in it for the quantitative estimation of the virus in solution.

6. *Soil Testing* :

In the studies on the correlation of available phosphorus and crop response, it was observed that Olsen's method of extracting available phosphorus gave a better correlation with crop responses for wheat in neutral and calcareous soils. The studies on the availability of soil phosphorus, as affected by different factors, showed that the available phosphorus increased with temperature and that the availability of phosphorus was low in water-logged or sterilized soils.

7. *Radio-Tracer Investigations*:

Experiments on spray and soil application of phosphatic fertilisers with maize, using tracer technique, have shown that 5 lbs per acre of spray application was as good as 80 lbs per acre dose of soil application. Ammonium phosphate proved to be the most efficient fertiliser for spray application.

All-India Soil and Land Use Survey

This organisation, located at the I.A.R.I. since 1958, has four regional centres *i.e.*, Delhi, Nagpur, Calcutta and Bangalore. Its primary objective is to carry out a standard detailed soil survey of catchment areas of six major river valley projects of the country, covering an area of about 78,000 square miles. During the six months period under report, a total area of 9.53 lakh acres was covered by detailed and reconnaissance survey, of which 2.02 lakh acres fall in the river valley project areas and 7.51 lakh acres in the other areas in the States of Madras, Mysore, Kerala, Andhra Pradesh, Maharashtra, Madhya Pradesh, West Bengal. Tripura, Uttar Pradesh and Punjab.

In all, 46 reports have been published during the period covering an area of 29.69 lakh acres and sent to the States concerned for comments and execution.

3. THE POST-GRADUATE SCHOOL

Inaugurated in 1958, the Post-Graduate School continued to make further progress for establishing the new pattern for a high-quality programme of post-graduate education in the various disciplines of agricultural sciences, Dr. R. W. Cummings,

Field Director, Rockefeller Foundation, kindly continued to work in an honorary capacity as the Acting Dean of the Post-Graduate School till November, 1960 when Dr. A. B. Joshi was appointed to the post of the Dean of the Post-Graduate School.

The third academic session of the School commenced on 16th October, 1960, and of the 592 applicants for M.Sc., and 294 for the Ph.D. course, 82 were admitted to the M.Sc. and 56 for the Ph.D. In addition, 21 Departmental candidates, 3 for the former and 18 for the latter course, were also given admission to give effect to the scheme of in-service training of the Institute staff. The total number of Post-Graduate students on the rolls on 31st December, 1960 was 305 (M.Sc. 176 and Ph.D. 129)—including two from Nepal. Also, one student from Netherlands was admitted for training in Community Development work.

Of the first batch of students admitted to the School in 1958, 3 Ph.D. students and 75 M.Sc. students completed all the academic requirements and were declared successful for the award of Ph.D. and M.Sc. degrees.

Besides the regular post-graduate training, three short courses of special training were organised during the latter half of 1960, namely, a 6 month course on Soil Survey commencing 1.12.60; a short course of training in Maize Breeding and Seed Production; and the third in Soil Testing Methods.

Other important developments in connection with the Post-Graduate School have been the setting up of the new degree-granting Division at the Institute—the Division of Agricultural Extension—and the nomination of the two distinguished scientists—Dr. K. S. Krishnan, M.A., D.Sc., F.R.S., LL.D., F.N.I., Director, National Physical Laboratory, and Dr. P. Maheshwari, D.Sc., F.N.I., Head of the Department of Botany of Delhi University—as Honorary members of the Post-graduate Faculty of the School.

4. GENERAL

(a) Meetings, Conferences and Deputations

The Director, the Heads of Divisions and Senior members of the staff attended meetings sponsored by the various Ministries of the Government of India, the Indian Council of Agricultural Research, the Commodity Committees and other bodies. In addition, they served on numerous other expert Committees constituted by various scientific organisations in the country and also helped the Central and State Public Service Commissions and Universities in the selection of scientific personnel.

Dr. B. L. Chona, Mycologist, was deputed to attend the VI Mycological Conference in London from 15th to 22nd July, 1960. He also presided over one of the sessions of the Conference dealing with Rust and Virus Diseases of Tropical regions.

Dr. M. S. Swaminathan, Cytogeneticist, was deputed to attend an International Symposium, held under the auspices of the F.A.O. and the International Atomic Energy Commission, on the effects of ionising radiation on seeds and its significance for crop improvement, from 8th to 12th August, 1960 in Germany. He was elected Chairman of the Symposium as also the Official Reviewed.

Dr. N. P. Datta, Special Officer, Dr. B. Ramamoorthy, Physical Chemist, and Dr. S. Digar, Soil Correlator (Red and Laterite Soil Region-I), were deputed to attend the 7th International Science Congress in the U.S.A. from 2nd to 26th August, 1960.

Dr. W. B. Sundara Rao, Soil Microbiologist, was deputed to the U.S.S.R. for training in bacterisation with Phosphobacterin from 13th October to 28th December, 1960.

Dr. M. K. Hingorani, Plant Bacteriologist, was on deputation on foreign service in Egypt in connection with an F.A.O. assignment with effect from 22nd July, 1960.

Shri B. S. Bajaj, Plant Pathologist, was deputed to U.S.A. for six months with effect from 18th July, 1960 for advanced training in the use of Radio-Isotopes in Plant Pathology under T.C.M. Programme.

Dr. A. T. Natrajan, Assistant Cytogeneticist, who was on deputation abroad for higher training since December, 1958 returned to I.A.R.I. and resumed his duties with effect from 29th December, 1960.

Sarvashri K. Swaminathan, N. M. Nimgade, M.A. Idnani and G. Ramchandra were away on deputation to Southern Railway, the U.S.A., Ghana and the U.S.A., respectively.

(b) Visitors

The Institute is visited by a large number of Indian and foreign visitors, including Heads of States and other dignitories, students from agricultural and other Colleges in the country, as also individual farmers and farmers' organisations.

Thirty five V.I.Ps., including His Imperial Highness the Crown Prince of Japan, visited the Institute during the period under report.

(c) Library

The total number of publications received in the Library during these six months was 1952. Fifty three new periodicals have also been added to the Library. The books issued on loan from the Library numbered 6,691 of which 690 were sent out to the scientific workers in the Universities and research institutions in the States. 12,035 readers made use of the Reading Room of the Library and consulted 45,154 books. In addition, literature references on various specific subjects were furnished to several correspondents on request.

A number of improvements in the Library service are being incorporated.

(d) Collections and Herbaria

Under the Plant Introduction and Exploration Organisation, 1112 samples of seed and planting material were introduced from abroad and 803 were collected from within the country, thus bringing the total number of the collection to 27,554.

Fifty seven specimens, belonging to 20 different species of Braconidae and 8 of Embioptera, and 14 slides of Fleas were added to the National Pusa Collection. In the Check-List of Indian Insects under preparation, 565 species of Sphecoidea, 493 species of Carabidae and 400 species of Noctuidae were listed.

Fifty two mycological specimens were added to the Herbarium (*Herbarium Cryptogamae Indiae Orientalis*), bringing the total number of accessions to 27,102. The number of fungal and bacterial cultures in the Indian Type Culture Collection was

1124 after the addition of 3 new cultures of fungi. In addition, 59 cultures of various plant Rusts and 55 of Plant Viruses were being maintained. Twelve mycological specimens, including 3 Type specimens, and 103 cultures of fungi and bacteria were supplied to various research workers and industrial concerns in the country and abroad at their request.

(e) Research Schemes

Work on 38 Schemes, sponsored by the Ministry of Food and Agriculture, Indian Council of Agricultural Research or other Commodity Committees, was in progress in the different Divisions of the Institute during the period under report.

(f) Supply of Pedigree Seeds

As usual, there was great demand for the seeds of improved varieties, particularly new N. P. wheats and vegetables; but owing to the limited facilities available at the Institute for general seed-multiplication, only 72,030 kg. of wheat seed could be supplied as against the demand of 7,02,270 kg. As regards other crops, 18,685 kg. of seeds, including 6,194 of vegetables, 2,648 of linseed, 1,667 of *bajra,* 1,331 of barley, 266 of *berseem,* 244 of maize and 247 kg. of gram, were distributed on payment. In addition, 4,500 rose plants of choice varieties were supplied to 250 indentors as also a large number of seedlings and nursery plants of fruit-trees, vegetables and ornamental plants.

(g) Advisory

In addition to the normal activities of research and post-graduate teaching, enquiries seeking advice on a variety of problems such as cultural practices, fertilizers, manures, chemical weedicides, cultivation of various field and vegetable crops and protection thereof against pests and diseases, identification of specimens of plants, insect pests and diseases, analysis of soil and water for irrigation, methods of soil conservation, cowdung gas-plant and soil-testing kits, supply of parasites of insect pests, use of algae in agriculture and hormones in improvement of crop yields, lay-out of ornamental gardens, fruit preservation techniques, etc. were attended to by various Divisions.

(h) Land and Buildings

The following buildings were completed during the period under report even though the electric connection has not yet been provided. Efforts are being made in this direction to enable us to make use of these buildings:

1. Fumigatorium in the Entomology Division.
2. Administrative Wing to Director's Office in connection with the establishment of P. G. School.
3. Laboratory building at Indore under the Wheat Rust Control Scheme.
4. Garage for trucks and jeeps.
5. Two Laboratory rooms under the Co-ordinated Wheat Rust Control Scheme (Botanical portion).
6. Regional Research Laboratory under "Pirrcom".

The construction of Cereal Research Laboratory, the Laboratory for Fundamental Plant Genetical Research, Insectary building and Extension to Mycology Division were in progress and construction of building for Horticulture Division, Quarantine House, buildings for the Agricultural Research Sub-Station, Karnal, Additional Wing to the Library and Entrance Gates of the Institute were taken up by the C.P.W.D.

Expenditure sanctions for Toxicological and Physiological Laboratory, Dispensary building, Tubewell at B.S.S. Pusa, Laboratory and Office building under the Plant Introduction and Exploration Organisation at Simla, Club and Social Centre and Residential buildings, were received from the Government, and C.P.W.D. were requested to take immediate steps in respect of construction.

The Ford Foundation have kindly placed at the disposal of the Government adequate funds for the construction of buildings for the two new Divisions of Agricultural Extension and Economics. The C.P.W.D. were approached for preparation of plans for these buildings.

II. REPORTS OF THE HEADS OF DIVISIONS

DIVISION OF AGRONOMY

(Dr. O. P. GAUTAM)

I. Weather and Crops

The weather data for the period under report are given in table below :

Mean Meteorological observations

Items / Months	Temp. °C				Rainfall in mm.		Mean relative humidity at 7A.M.	Mean wind velocity in Km/per hour	Mean hours of bright sunshine	Mean Evaporation from USA Standard evaporimeter (mm.)
	Mean max.	Dep. from normal	Mean min.	Dep. from normal	Total	Dep. from normal				
July '60	34·2	−0·9	26·5	−0·2	328·5	+111·6	83·0	5·6	6·0	9·1
Aug.'60	32·1	−0·8	25·7	+0·1	315·2	+154·8	90·2	4·3	4·8	5·3
Sept.'60	34·3	+1·1	23·9	−0·1	4·2	−126·7	76·4	3·1	9·3	7·4
Oct.'60	31·5	−0·5	16·6	−1·0	69·2	+ 5·6	76·5	3·5	8·9	6·1
Nov.'60	27·7	0·0	8·3	−1·5	0·0	− 3·4	69·3	2·2	9·9	4·7
Dec.'60	22·7	+0·2	4·7	−1·7	0·0	− 2·0	78·6	2·4	8·7	2·4

The total rainfall received from July to December, 1960 was 717.1 mm. which was 139.9 mm. above normal. Failure of rains in September resulted in a setback to the standing *Kharif* crops. October rains were well distributed and enabled sowing of *Rabi* cereals on conserved moisture in most of the fields. In the rainfed area, gram was sown on residual moisture after *jowar* or *bajra* also wherever the crops were harvested soon after October rains. Germination of *rabi* crops was normal both under irrigated and rainfed conditions.

The average yields of principal *Kharif* crops are given below :

Crop	Yield md./acre
1. Maize (grain)	7·54
2. *Jowar* (green fodder)	218·8
3. Maize (early green fodder)	257·9
4. Cotton	8.2

The average yields of crops were below normal on account of heavy rains in July and August.

II. Research Projects

The research programme of the Division is divided into the following sections:

(1) Soil Fertility (2) Field Crops (3) Vegetable and Commercial Crops (4) Cattle Breeding and Management; and Schemes on (i) All India Fertiliser Use (Model Agronomic Experiments Scheme and Co-ordinated Scheme of Simple Fertiliser Trials in Cultivators' Fields) (ii) Weed Control (iii) Irrigation Investigation (iv) Agricultural Extension (v) Plant Tissue Tests and Spray Fertilisation (vi) Improvement of pasture grasses and legumes. Besides, two independent Sections of Agricultural Statistics and Agricultural Economics are located and functioning in the Division. The experimental results in respect of the various research projects are reported below :

1. *Soil Fertility Section* :

(i) *Permanent Manurial Experiment* (*I.A.R.I.*).—This project was started in 1958-59 in order to study the effects of manures and fertilisers on the yield and quality of crops and the nutrient status of the soil. The rotations followed were :

A. Maize-Fallow-Cotton-Fallow-Wheat.

B. Maize-Peas-Cotton-Green manure-Wheat.

The first cycle of the rotation will be completed in 1961. The yield data of different crops will therefore, be reported next year.

(ii) *Permanent Rotation Experiment* (*I.A.R.I.*).—Yields of cotton, maize and maize+cowpeas (fodder) relating to the *Kharif* 1960 season are presented below :

Effect of rotations on the yield of Cotton

Rotations	Yield md./acre
C. Cotton-Berseem-Fallow-Wheat (2 years)	11·84
D. Maize+Cowpeas-Wheat-Cotton-Berseem (2 years)	11·43
G. Fallow-Wheat-Fallow-Peas-Cotton-Fallow (3 years)	9·60
H. Fallow-Wheat-Cotton-Fallow-Sugarcane (3 years)	9·50

Yields of cotton in rotations 'C' and 'D' were about 25% more than those obtained in rotations 'G' and 'H'.

Effect of rotations on the yield of Maize

Rotations	Yield md./acre
B. G.M.-Potato-Maize-Peas (2 years)	9·61
E. Maize-Potato-Sugarcane-Sugarcane (3 years)	12·72
F. G.M.-Wheat-Maize-Peas (2 years)	11·06
I. Maize+Cowpeas-Wheat-Fallow-Peas-Maize-Berseem (3 years)	10·38

Maize crop grown after sugarcane yielded the maximum. There was an increase of about 32% in maize yield in case of rotation E over rotation B.

Effect of rotations on the yield of maize+cowpeas (fodder)

Rotations	Yield md./acre
A. Maize+cowpeas-Wheat-Fallow-Wheat (2 years)	328·92
B. Maize+cowpeas-Wheat-Cotton-Berseem (2 years)	382·89
I. Maize+cowpeas-Wheat-Fallow-Peas-Maize-Berseem (3 years) . .	351·38

Yields of green fodder of maize+cowpeas obtained from the two rotations B and I, where berseem was the preceding crop, were substantially higher than those obtained for rotation 'A' where the preceding crop was wheat. The results clearly indicate that the residual fertility after berseem fertilised with phosphate contributed to the increased crop production in the following season.

(iii) *Effect of low doses of phosphate on Berseem and after effects on Wheat.*— After completion of the third cycle of the rotation in this experiment (3 crops of manured berseem followed by 3 crops of unmanured wheat), *jowar* for green fodder was grown in *Kharif* 1960 to study the status of residual fertility in the plots under the different treatments followed in the preceding years.

The yield results indicated that the various treatments did not differ significantly in their after effects on the green fodder yield of *jowar*. There was, however, a definite trend in yield which increased with the increase in the level of P_2O_5 applied as F.Y.M. or superphosphate or as their combinations. These results, thus, showed that variations in soil fertility resulting from differential fertilisation of berseem with phosphate persisted to a certain extent, even after growing three successive crops of unmanured wheat.

(iv) *Phosphate manuring of legumes under rainfed conditions.*—The experiment was started with a view to study the effects of phosphate applied at different levels, on the yield of green fodder of '*guar*' under rainfed conditions and the after effects on the yield of wheat, as against direct manuring of wheat. The yields of green fodder of '*guar*' obtained during *kharif* 1960 are given below :

Treatments (Fertiliser doses/acre)	'*Guar*' green fodder md./ acre
A. *Guar* : no manure ; Wheat : no manure	56·6
B. *Guar* : 25 lb. P_2O_5 ; Wheat : no manure	63·0
C. *Guar* : 50 lb. P_2O_5 ; Wheat : no manure	67·7
D. *Guar* : 75 lb. P_2O_5 ; Wheat : no manure	81·2

Treatments (Fertilizer dose/acre)	'Guar' green fodder md./acre
E. *Guar* : no manure ; Wheat : 20 lb. N	57·3
F. *Guar* : 25 lb. P_2O_5 ; Wheat : 20 lb. N	51·6
G. *Guar* : 50 lb. P_2O_5 ; Wheat : 20 lb. N	59·6
H. *Guar* : 75 lb. P_2O_5 ; Wheat : 20 lb. N	83·4
I. *Kharif* : fallow; Wheat: no manure	..
J. *Kharif* : fallow ; Wheat : 20 lb. N	..
K. *Kharif* : fallow ; Wheat : 20 lb. N +25 lb. P_2O_5	..
S.Em.	±5·09
C.D (5%)	14·62

There was a distinct response of *guar* to P_2O_5 application. Significant differences the yield of *guar* were obtained when P_2O_5 was applied at 75 lb. per acre.

(v) *Hubam clover as mixed crop in 'Wheat-maize' cereal rotation.*—Maize No. was grown during *kharif* 1960 after Hubam clover was buried for green manuring in ne preceding season. The results obtained are given below:

Treatments (Fertiliser dose/acre)	Maize grain md./acre
A. Wheat-fallow : no manure	..
B. Wheat-Maize : 40 lb. N to wheat	7·23
C. Wheat-Maize : 40 lb. N to maize	11·82
D. Wheat-Maize : 40 lb. N to each crop	10·90
E. Wheat and clover for fodder and G.M.-Maize : no manure	6·32
F. Wheat and clover for fodder-maize : 40 lb. N to maize	12·16
G. Wheat-Maize : 80 lb. P_2O_5 to clover	5·81
H. Wheat and clover for G.M.-Maize : no manure	8·79
I. Wheat-Maize : 40 lb. N to maize	11·29
J. Wheat and clover-Maize : 80 lb. P_2O_5 to clover	10·27
K. Hubam clover G.M.-Maize : no manure	10·70
L. Wheat-*Sannhemp* G.M. : no manure	..
S. Em.	±1·08
C.D. (5%)	3·12
C.D. (1%)	4·22

As in previous years, direct manuring of maize with nitrogenous fertiliser gave the best yields. Good response to green manuring with Hubam clover was obtained when the clover was not cut for fodder and the entire stuff was buried for green manuring. The treatment J (80 lb. P_2O_5 to the clover grown mixed with wheat) gave promising results.

(vi) *Permanent manurial and rotation experiments (Pusa)*.—The yield of maize obtained with various treatments in this experiment during *kharif* 1960 is given in the following table:

Plot No.	Treatments (Manure or Fertiliser dose/acre)	Maize grain (md./acre) 'A' series	'B' series
1	No manure	3·33	1·39
2	F.Y.M. 4000 lb.	11·81	16·47
3	F.Y.M. 8000 lb.	11·93	22·40
4	F.Y.M. 4000 lb. and Rape cake 20 lb. N	11·20	16·35
5	Rape cake 40 lb. N	8·54	12·41
6	Amm. sulphate 40 lb. N	2·91	4·54
7	Pot. Sulph. 50 lb. K_2O	6·24	8·84
8	Superphos. 80 lb. P_2O_5	7·87	12·11
9	PK as in plots 8 & 7	8·66	9·20
10	NPK as in plots 6, 8 & 7	10·84	12·90
11	NP as in plots 6 & 8	5·21	10·66
12	G.M. in cereal rotation	G.M.	G.M.
13	No manure	2·85	5·03
14	NK as in plots 6 & 7	2·97	5·87
15	G. M. and legumes in the rotation	4·84	G.M.
16	As in plot 15 and 80 lb. P_2O_5 to G	7·93	G.M.
17	No G.M. and no legume in the rotation	2·47	2·64
18	No manure	2·31	2·96

The differences in the yield of maize grain in the two series were due to growing a mixed crop of maize and '*arhar*' in series A and a pure crop of maize in series B.

In both the series, the responses to manures and fertilisers were almost similar. Highest yields were obtained with F.Y.M. applied at 8000 lb./acre. Organic manure showed better performance than the artificial fertilisers. In the latter case, NPK treatment gave the highest yield of maize.

The crop was affected adversely in the early stages of growth due to drought.

(vii) *New Manurial Experiments, Pusa* (1932-33).—Maize was grown in *kharif* 1960 and the results obtained are given below:

Treatments (Manure and Fertiliser dose/acre)	Maize grain md./acre
A. No manure	7·21
B. F.Y.M. 8000 lb.	15·88
C. Rape cake 40 lb. N	14·74
D. Amm. sulphate 40 lb. N	8·98
E. Pot. sulphate 50 lb. K_2O	7·06
F. Superphosphate 80 lb. P_2O_5	8·23
G. PK as in treatments F & E	6·63
H. NPK as in treatments D, F & E	8·39
I. NP as in treatments D & F	9·37
J. NK as in treatments D & E	8·63
S.Em.	±1·18
C.D. (5%)	3·31
C.D. (1%)	4·39

In this experiment also, F.Y.M. applied at 8000 lb./acre gave the highest yield and it was significantly superior to all other treatments, except rape cake (C) which was at par with the F.Y.M. treatment. The differences among the fertiliser treatments were not significant.

The crop was affected adversely in the early stages of its growth due to scarcity of rainfall.

(viii) *Residual value of phosphate on rotation of crops.*—This experiment was started in 1954 and has been in progress at the same location. The rotation followed was fallow-wheat-*jowar*-berseem. Both phases of the rotation were studied. The phosphate treatments consisted of 10, 20 and 40 lb. P_2O_5 per acre and they were applied so as to enable the study of the direct, residual and cumulative effect on each of the crop in the rotation. A basal dressing of 20 lb. N was applied to each plot and to each crop in the rotation except to the control plot. During the *kharif*, 1960 the experimental crop was *jowar* (fodder). In the other phase of the experiment, the field was fallow.

This year's results did not indicate any effect of 20 lb. N applied to the *jowar* crop. 20 lb. P_2O_5 applied in combination with 20 lb. N increased the yield by about 150 mds. over control or 20 lb. N. Increased dose of P_2O_5 from 20 to 40 lb. had no beneficial effect. Highest yield was obtained when 40 lb. P_2O_5 was applied to each crop in combination with 20 lb. N per acre.

2. *Field Crop Section* :

(i) *Spacing*-cum-*fertility trial on sorghum.*—This was the first year of the investigation comprising of two varieties (Texas 610 and Texas 263), three row spacings

18″, 24″ and 30″) and four nitrogen levels (0, 30, 60 and 90 lb./acre). Yield results are given in table below :

Treatments		Yield of *jowar* grain (md./acre)		
Varieties	Texas 610	12·68	S. Em.	±0·37
	Texas 263	3·16	C.D. at 5% level	1·12
Row spacing	18″	6·09	S. Em.	±0·45
	24″	5·30	C.D. at 5% level	1·36
	30″	4·67		
Nitrogen doses	0	7·67	S.Em.	±0·38
	30 lb.	8·14		
	60 lb.	7·97		
	90 lb.	7·94		

Jowar variety Texas 610 gave four times the yield of Texas 263 and the difference between the two was highly significant. Spacing of rows at 18″ gave the highest yield and was significantly superior to spacing of rows 30″ apart. Nitrogen levels did not indicate any differential response. It was observed that the tall variety (Texas 263), suffered very much more due to bird damage than the short variety (Texas 610).

(ii) *Phosphorus fertilisation of cotton by radio-tracer technique.*—Yields of seed cotton obtained with the various treatments are given below:

Effect of different treatments on yield of seed cotton

Treatments	Yield (md/acre)	Treatments single band	Yield (md/acre)	Treatments double band	Yield (md/acre)	Additional treatments	Yield (md/ac.)
20 lb. P_2O_5/acre	13·15	0″ broadcast	12.76	0″ broadcast	13·28	60 lb. N+ 40 lb. K_2O	14·90
40 lb. ,,	13·33	3″below surface	14·16	3″ below surface	13·57	40 lb. P_2O_5 in single band 3″ below surface	13·25
60 lb. ,,	13·73	5″ below surface	13·28	5″ below surface	13·36	40 lb. P_2O_5 in double band 3″ below surface	13·44
'F' test	Not sig.	'F' test	Sig. 5%	'F' test	Not sig.	'F' test	Not sig.
C.D.	..	C.D.	0·95	C.D.	..	C.D.	..

Application of phosphate 3″ below the surface and directly below the seed in a single band increased the yield of cotton by about 1.4 mds. over that obtained with broadcast treatment and this difference was significant. Doses of phosphate and the double band placements at different depths did not show significant differential responses. Single band placement 3″ below the surface was most conducive to higher production of cotton.

(iii) *Plant population-fertility relationships for maize.*—This was the second year of the trial. The yield data are given below:

Treatments		Grain yield of maize md./acre		
Row spacing	24″	12·14	S. Em.	±0·78
	30″	10·61	C.D. at	
	36″	9·34	5%	2·29
Nitrogen dose	40 lb. N per acre	8·75	S. Em.	±0·78
	80 lb. N per acre	11·15	C.D. at	
	120 lb. N per acre	12·21	5%	2·29
Maize varieties	K.T. 41	9·91	S. Em.	±0·78
	Illi. 1656 (Dent Hybrid)	10·52	C. D. at	2·29
	Texas : 26 (Dent Hybrid)	11·70	5%	

With a row spacing of 24″, maize yielded the highest. Grain yield decreased with increase in the row spacing. Application of 80 lb. nitrogen per acre gave the most economic yield. The difference of 2·40 mds. in grain yield due to 80 lb. N over 40 lb. N was found to be significant. The varieties did not differ significantly in grain yield. Next higher dose of 120 lbs. N did increase the yield but the difference was not significant over 80 lb. N.

The crop suffered seriously due to water logging in the seedling stage and could not recoup till the end. This was the main reason for the poor yields obtained during this season in comparison to the last year's result.

3. *Vegetable and Commercial Crops Section:*

(i) *Manurial experiment on cauliflower.*—The crop was transplanted in the first week of November and as per schedule application of major plant nutrients has been completed. Growth observations are being recorded. Uptake of nitrogen, phosphorus and potash will be studied at harvest time.

(ii) *Manurial-cum-varietal trial on peas under irrigated conditions.*—Two varieties of peas N. P. 29 and Bonneville were sown on the 15th November in the experimental plots to study the differential response of doses of nitrogen, phosphorus, potash and farmyard manure. Growth observations are being recorded.

(iii) *Manurial experiment on turnip.*—The crop was sown in the first week of November and as per schedule application of major plant nutrients has been completed. Growth observations are being recorded. Uptake of nitrogen, phosphorus and potash will be studied at harvest time.

(iv) *Vegetable growers' holdings.*—Four vegetable growers' holdings, namely manured with F.Y.M., sludge, artificial fertilisers and ½ F. Y. M. + ½ artificial fertilisers previously located in M.B. 9 have been shifted to M.B. 6. As per schedule, application of manures and fertilisers was taken up in various holdings. Sowing of turnip, cabbage, cauliflower, potato, tomato, wheat, oats, berseem and peas was completed during October and upto 15th of November.

4. Cattle Breeding and Management Section:

(i) *The Sahiwal herd.*—The Sahiwal herd is being built up gradually by proper selection of good animals and culling out the poor stock. At the end of June 1960, there were 121 Sahiwal animals. The strength, on 31st December 1960, stood at 116. The net average yield of milk per cow per day during the period under report was 20.1 lbs. and the averall average yield of milk was 10.8 lbs. The average lactation yield of the herd was 5428 lbs. Two cows have given over 8000 lbs. of milk each in 306 days. The average age at first calving was 2 years, 10 months and 23 days. There was an outbreak of foot and mouth disease for which aid was sought from the Indian Veterinary Research Institute. Seven animals got a serious setback due to this disease and the after effects may persist for a considerable time. The experiments on rearing Sahiwal calves on skim milk, supplementing the calves' ration with antibiotics and inducing artificial lactation in sterile cows were in progress. One Sahiwal bull was sold during the period under report.

(ii) *'Murrah' buffaloes herd.*—At the end of June 1960 the strength was 24. The present strength is 31, with 11 buffaloes which are all in milk and will complete lactation after a few months. The buffalo calves have been given a supplement of urea to see its effects on their general growth. Two young Murrah buffalo bulls were sold during the period under report.

5. *Weed Control Investigation Scheme* :

(i) *Control of weeds in maize.*—The grain yield data from field experiment with maize involving the use of 2,4-D, Crag herbicide and Simazine (a triazine compound) in conjunction with other cultural practices are given below:

Treatment	Grain yield in md./acre
1. Unweeded control	3·2
2. Crag herbicide pre-emergence 3 lbs.	7·2
3. 2, 4-D Pre. at 1 lb. +2, 4-D Post. at 12 oz.	6·7
4. Hoeing at 3 weeks + earthing up	8·9
5. Hand weeding once only at 3 weeks	8·9
6. Hoeing at 3 weeks + earthing up+2, 4-D Post. 12 ozs.	9·8
7. Simazine (10 days after sowing) at 2 lbs.	11·6
8. Simazine at 2 lbs. +2, 4-D Post. 12 ozs.	12·9
9. Hand weedings (4 times)	13·9
S. Em.	±0·64
C.D. at 5% level	1·86

Significant increase in grain yield occurred under the treatment Simazine at 2 lbs. plus 2,4-D post-emergence at 12 ozs. Substantial reduction in weed density was affected by this treatment. Though the 4 times hand weeding treatment secured the most efficient weed control and thereby stepped up the grain yield of the crop, it was time consuming and laborious.

(ii) *Weed control in cotton.*—The effect of pre-emergent application of 2, 4-D (4 lbs./acre), T.C.A. (20 lbs./acre) and other cultural practices was studied in a replicated field trial.

The prevalent weeds were: *Echinochloa colonum, Digitaria spp. Dactyloctenium aegyptium, Eleusine spp., Cyperus rotundus, Digera arvensis and Justicia quinquangularis.* The data on weed population indicated that though the chemicals proved helpful in controlling weeds in the early stages, their effect was not persistent till the end due to heavy rains.

The yield of *kapas* did not increase under any one of the treatments except under the three hoeings. The results showed the essentiality of weed control at this later stage in the cotton crop. Further it appeared that the crop received some stimulus other than weed removal by the hoeings.

The interaction between the various treatments was not significant.

6. *Irrigation Investigation Scheme:*

(i) *Inter-relationship of varying water regimes and manurial factors on potato.*—This experiment comprised of all combinations of three moisture regimes (irrigation applied at about 0.25, 0.5 and about 0.75 atmosphere soil moisture tension), three levels of nitrogen (50,100 and 150 lb. N per acre) and three levels of potassium (0, 75, and 150 lb. K_2O/acre). The experiment was repeated at the same site as in the preceding year but fresh treatments were included without re-randomisation of the treatments. A crop of maize and cowpeas was taken to minimise the residual effect of the previous year's treatments. The effects of the treatments are recorded in table given below:

Effect of irrigation, nitrogen, phosphorus and potassium on the yield of potatoes (md./acre).

	n_0	n_1	n_2		k_0	k_1	k_2	Mean
t_0	275	292	314	t_0	267	300	314	293
t_1	235	251	231	t_1	216	238	264	239
t_2	215	234	236	t_2	211	237	237	228
$T'.N' = 9{\cdot}3 \pm 5{\cdot}18$				p_0	239	239	259	246
$T'.K' = 10{\cdot}5 \pm 5{\cdot}18$				p_1	229	268	277	258
$P'.K' = 15{\cdot}7 \pm 7{\cdot}20$				p_2	226	268	278	257
				Mean	231	258	271	

t, n, p, k, denote 'moisture-tension', 'nitrogen', 'phosphorus' and 'potassium' respectively. 0, 1, 2 denote the levels of the factors studied. Single dash denotes linear component of the responses.

Frequent irrigations at two soil moisture tensions (about 0.25 soil moisture tension=irrigation at 7—12 day interval during November to January) increased the yield of potatoes by about 65 mds./acre, as compared with delayed irrigations at 14—20 day intervals. Frequent irrigations also enhanced the responses to nitrogen and potassium.

The response to potassium was the most marked, that of nitrogen was less so and to phosphate was still low. P and K showed strong interaction.

(ii) *Studies on the relationship of irrigation and nitrogen levels on cotton.*—An experiment comprising of all combinations of the irrigation and nitrogen levels was conducted on the cotton crop variety H. 14, sown early in May 1960. Irrigations applied during pre-monsoon period did not increase the yield of seed cotton. This was not in accord with the results obtained in the preceding year. The early break of monsoon rains in the end of June probably wiped off the advantage of the pre-monsoon irrigation. Irrigations during the monsoon season were also without effect because of the good rain received during July and August which left sufficient moisture for the crop to mature in spite of less rainfall in September. Nitrogen application also did not result in any significant effect on yield of seed cotton which was 11:19 mds. per acre.

7. Plant Tissue Tests and Spray Fertilisation Scheme :

Out of the 8 field trials in progress under the scheme, two on cotton and sugarcane were conducted during the *Kharif* 1960. The remaining 6 were laid out in *Rabi* 1960. Results from the following projects are reported.

(i) *Spray Fertilisation Experiment on Cotton.*—This experiment was initiated in 1958 with the object to study the relative efficiency of soil and spray application of nitrogen and phosphorus. The results obtained are as under:

Treatment/$\frac{1}{8}$acre		Yield of seed cotton in md./acre
Nitrogen at	20 lb.N	10·09
	40 lb.N	9·89
	60 lb.N	9·97
Phosphorus at	15 lb. P_2O_5	9·41
	30 lb. ,,	10·06
	45 lb. ,,	10·44
Methods of application . .	Soil application	10·26
	Foliage spray	9·73
	$\frac{1}{2}$ soil + $\frac{1}{2}$ spray	9·92
Additional treatments . .	Control	9·31
	80 lb. N + 45 lb. P_2O_5 applied to soil.	9·10
	100 lb. N + 45 lb. P_2O_5 applied to soil.	9·65

Fertiliser levels and their methods of application had little effect on the yield of cotton. The range of variation in yield under the experiment was from 9.10 mds. to 10·46 mds per acre. The lack of response to fertiliser application indicates that there may be other factors which limited crop production on this field.

(ii) *Comparative efficiency of foliar and soil application of micronutrients for berseem production.*—In this project, a study of reddening of plants was carried out

during December, 1960, with special reference to reduction in yield and the status of NO_3 and P_2O_5 uptake as indicated by rapid plant tissue tests. The results are as under :

Fertiliser treatment (soil application)	Weight per plant (gm.)		
	Green plants	Medium red plants	Completely red plants
1. Control	0·84	0·76	0·38
2. 40 lb. P_2O_5	1·03	0·58	0·39
3. 60 lb. ,,	0·96	0·95	0·44
4. 80 lb. ,,	1·07	0·84	0·65
5. 120 lb. ,,	1·24	0·70	0·50
AVERAGE	1·05	0·86	0·48
% loss in yield on account of reddening		19·4	54·8

It was observed that the medium red and completely red plants showed a higher test for phosphate and lower test for NO_3 than the green plants when subjected to rapid tissue test analysis. A few plants of each category were uprooted for nodule study. The red and medium red plants lacked nodules on roots whereas the green plants had numerous nodules. Confirmatory tests that reddening in berseem may be due to lack of nitrates or other nutrients are in progress.

8. *All India Fertiliser Use Projects* :

Coordinated Agronomic Experiments Scheme, which comprises of two parts namely (i) Co-ordinated scheme of Simple Fertiliser Trials on cultivators' fields and (ii) Model Agronomic Experiments Scheme, was initiated by the Indian Council of Agricultural Research, New Delhi in 1956 and has been in operation since then as a part of the second five year plan programme.

(i) *Co-ordinated Scheme of Simple Fertiliser Trials on Cultivators' fields.*—Three types of experiments were conducted in 135 districts out of the 200 districts selected for the purpose. The progress reports received from the different States indicate that 7410 Simple Fertiliser Trials have been conducted on *Kharif* and *Rabi* crops upto November, 1960. The yield data received for the last season from the States are being compiled for statistical analysis. The analysis work for the 1957 and 1958 has been completed and the report is being prepared for submission to the Indian Council of Agricultural Research for publication. Efforts are being made to extend the work to the remaining districts which have not been covered for experimentation so far. The training of the staff in the States remained in progress.

(ii) *Model Agronomic Experiments Scheme.*—Under the scheme complex experiments involving factors such as levels and forms of nitrogen, phosphate and potash, in combination with seed rate, sowing dates, types of fertilisers, rotations and depths of irrigation are being conducted. Experimental work is in progress in 33 out of 34 centres proposed under this Scheme in the different agro-climatic regions. The experimental work has not been taken up at Khudwani in Jammu and Kashmir. The number of complex experiments conducted during 1960-61 at the 34 centres is 214 with 117 in *kharif* and 97 in *rabi.*

The data pertaining to the experiments conducted during the period under report are being compiled for statistical analysis.

9. *Improvement of Pasture Grasses and Legumes :*

(i) *Effect of nitrogen fertilisation and cutting interval on the forage yield and protein content of perennial grasses under irrigated conditions.*—The treatment combinations were three grasses: Napier, Setaria and Para; 3 levels of nitrogen: 0, 80 and 160 lb. N as ammonium sulphate and three intervals of cutting: 30, 45 and 60 days. The fertiliser doses were applied in three equal splits in the middle of March, July and September. First cutting for green fodder was taken on 15th April, and last in the middle of December. During the period 4, 6 and 8 cuttings were taken with 60, 45 and 30 days interval of cuttings respectively. All the three grasses were productive upto the middle of December. Samples were drawn from each treatment for the estimation of dry weight and protein content in the forage produced. The results are given below:

Effect of Main Treatments on the Green Herbage yield (md./acre).

Perennial grasses	Yield	Nitrogen levels	Yield	Cutting interval	Yield
Napier . .	1468·6	0 lb. N/acre .	910·2	30 days .	910·2
Setaria . .	1098·2	80 lb. N/acre .	1175·7	45 days .	1175·7
Para . .	853·8	160 lb. N/acre .	1134·7	60 days .	1334·7
S.Em . .	±25·3		±25·3		±25·3
'F' test .	Sig.		Sig.		Sig.
C.D. at 5% .	74·3		74·3		74·3

Napier grass gave 370 and 615 mds. per acre more yield than Setaria and Para respectively. These differences were significant. On the average, 160 lb. N/acre with 60 days' interval gave 424 and 159 mds. more yield than with 30 and 45 days' intervals respectively and these differences were significant.

The interaction of nitrogen doses and cutting intervals was found to be significant as is evident from the data presented in the table given below :

Effect of cutting intervals and nitrogen levels on the Green herbage yield of grasses md./acre.

Nitrogen levels	Cutting intervals		
	30 days	45 days	60 days
0 lb. N/acre	710·7	1014·2	1002·3
80 lb. N/acre	905·9	1224·5	1392·3
160 lb. N/acre	1226·3	1350·1	1622·7
S.Em . . .	±43·87		
'F' test . . .	Significant		
C.D. at 5%	159·83		

With higher level of nitrogen and longer interval of cutting, the yield increased significantly. Other interactions were not significant. Napier grass gave the highest yield (2185.8 mds./acre) with an application of 160 lb. N/acre and 60 days' interval of cutting. The other two grasses also gave maximum yield with this very combination.

(ii) *Effect of nitrogenous fertiliser applied at varying intervals on the yield and protein content of Setaria sphacelata (Kazungula grass) under irrigated conditions.*—The effect of 2, 4 and 6 split applications of 80, 120, 160 and 200 lb. N/acre was studied on the green fodder yield of Kazungula grass. Two more treatments were included in the study (control with 40 lb. P_2O_5/acre and another without P_2O_5). In all, seven cuttings were obtained during the period extending from middle of April to the end of December.

The green herbage yield of *Setaria sphacelata* (Kazungula grass) increased with increasing levels of nitrogen. However, the differences were not significant. Two or four split applications of nitrogen did not have any advantage, whereas six split applications indicated increase in yield. But the differences due to split applications were also not significant.

(iii) *Relative response of perennial grasses to different levels of nitrogen, phosphate and potash under rainfed conditions.*—The treatments consisted of 3 levels of nitrogen (0, 40 and 80 lb. N/acre as ammonium sulphate): 3 levels of phosphate (0, 30 and 60 lb. P_2O_5/acre as superphosphate) and 3 levels of potash (0, 30 and 60 lb. K_2O/acre as muriate of potash) on the green fodder yield of three perennial grasses *viz., Chloris gayana* (Rhodes), *Urochloa mosambicensis* (Liver seed grass) and *Panicum maximum* (green panic).

Phosphate and potash fertilisers were placed about 3 inches deep on either side of grass rows after the onset of monsoons. The nitrogenous fertiliser was applied in two equal splits during the growth period of grasses. The results are given below:

(i) Perennial Grasses	Yield of green herbage (md./acre)	(ii) Nitrogen levels	Yield of green herbage (md./acre)
Urochloa mosambicensis (Liver seed grass)	392·2	0 lb. N/acre	281·9
Panicum maximum (Green panic)	290·9	40 lb. N/acre	299·0
Chloris gayana (Rhodes)	207·1	80 lb. N/acre	382·7
S.Em.	±7·9		±7·9
'F' test	Sig.		Not sig.
C.D. at 5%	35·4		..

(iii) Phosphate levels	Yield of green herbage (md./acre)	(iv) Potash levels	Yield of green herbage (md./acre)
0 lb. P_2O_5 /acre	303·6	0 lb. K_2O/acre .	268·3
30 lb. ,, ...	292·6	30 lb. ,, . .	297·6
60 lb. ,, ...	260·2	60 lb. ,, . .	305·5
S.Em. . . .	±7·9		±7·9
'F' test . . .	Not sig.		Not sig.

Urochloa mosambicensis (Liver seed grass) gave 102 and 195 mds./acre more yield than *Chloris gayana* (Rhodes grass) and *Panicum maximum* respectively. These differences were found to be significant. The green herbage yield of all the three grasses increased with increasing levels of nitrogen and potash but the differences were not significant. Phosphate alone had no effect on the yield. None of the interactions was significant.

(iv) *Effect of levels of phosphate on seed and fodder production of Medicago sativa under irrigated conditions.*—Four levels of phosphate fertilisation including control (9, 90, 120 and 160 lb. P_2O_5/acre) were used. The fertiliser was applied in two equal splits, one half in November and the other half in February. It was placed on either side of the lucerne rows. In all, lucerne gave seven cuttings. The seed production was rather poor owing to the unfavourable weather conditions.

(v) *Effect of varying levels of phosphate fertilisation on green fodder yield of Mucuna cochinchinensis* (*Velvet beans*).—The treatments consisted of four levels of phosphate applied as superphosphate (0, 30, 60 and 90 lb. P_2O_5/acre). The fertiliser was placed about half an inch below the seed.

Velvet beans did not show any response to varying levels of phosphatic fertiliser application.

(vi) *To study the role of grasses and legumes in soil and water conservation.*—An experiment has been started with the following plant species treatments during the period under report :

1. Urochloa spp.
2. Chloris gayana.
3. Cenchrus ciliaris.
4. *Bajra.*
5. *Bajra*+Mecuna cochinchinensis.
6. Control.

Grasses were established in the month of August. The stands of *Chloris gayana* and *Urochloa* grasses were better than others. For the subsequent years observation will be recorded on canopy development, splash studies, soil aggregates, infiltration rate, moisture percentage at various depths, carbon, total nitrogen, available potash and available phosphate content of the soil.

Seed Supply.—The following quantities of seeds of improved varieties of crops ere supplied to State Governments and individual farmers :

Crop	Quantities
1. Wheat	496·5 mds.
2. Peas	60·3 mds.
3. Oats	38·9 mds.
4. Berseem	7·1 mds.
5. Gram	4·1 mds.
6. Miscellaneous	0·9 md.
TOTAL	607·8 mds.

Section of Agricultural Statistics :

(i) *Advisory and Training.*—A large number of layout plans for field and oratory experiments were prepared and voluminous data on the various research jects were statistically analysed and the reports on the results obtained were pre- ed and sent to the respective Divisions. Further, training in Experimental Statistics given to (i) the students of Post-graduate School and (ii) State Assistant Soil emists of Soil Testing Service Scheme, Division of Chemistry, Indian Agricultural search Institute. Advice was also given to the research staff and the post-graduate dents of the Institute in designing of new experiments and also in the statistical alysis and interpretation of the data on their research problems.

(ii) *Research Projects.*—(a) *Genetical aspects of milk improvement in Sahiwal rd.*—The data on dams and daughters for the period of 28 years beginning from 1932 re collected and lactation yields were tabulated progeny-wise to study the improve- ent in milk yield.

(b) *Bulletin on I.A.R.I. Herd.*—Prior to the preparation of the bulletin, a liminary examination of the data on wet and overall averages of milk, average wet d dry periods of milking cows and lactation yields of the herd was considered neces- y. The information on (i) wet average, and (ii) overall average has been collected d also tabulated since 1914-15 to date. The period of twelve months—April to arch—was taken to work out the average for each year.

(c) *Crop cutting Experiments in the Intensive Cultivation Scheme villages ached to I.A.R.I.*—The crop cutting experiments during *kharif* 1960 were conducted the villages of the Intensive Cultivation Scheme, I.A.R.I. with a view to find out production potential of T. 55 variety of *bajra* and the response of *bajra* to N & P tilisation. In order to study these aspects, 30 cuts of size 1/80 acre each were taken m five villages. The statistical analysis of yield data did not indicate significant ferences between the varieties although the variety T. 55 gave a little better yield than local variety. The application of N & P (40 lb. N as ammonium sulphate and 20 P_2O_5 as superphosphate per acre) either placed or broadcast did not show significant provement over the control plot. Neither there was any significant interaction tween the varieties and the fertiliser treatments.

(iii) *Investigations.*—During the period under report, data from seventeen experimental projects of the following Divisions of the Institute were statistically analysed and the results sent to the respective Divisions.

Divisions	Number of Projects
Agronomy	12
Entomology	3
Chemistry	1
Mycology	1
	17

11. *Agricultural Economics Section:*

Group A : Research Projects

Section I : Farm Economics

(a) *Cost of maintenance of livestock on farmers' holdings* 1959-60.—With increase in the size of holdings, the strength of stock tends to rise and labour costs per head of animal get reduced. There is, however, no such trend in respect of feed costs per animal as house-grown produce is fed regardless of the market price and of the productivity of the stock (Annexure: Table 1).

(b) *Distribution of available labour (human and bullock) supply on farmers' holdings* 1959.—A study of this distribution, monthwise showed distinct peaks (April October) and troughs (January, June and July) corresponding to the agricultural operational cycle. Rise in seasonal demand was met partly by working longer hours and in the case of human labour to some extent by deducting labour from attendance on cattle. As the holding size rises, with adult males, the fraction spent on crops and cattle drops and that on non-gainful employment increases. With females, the opposite trend was observed. Drought animals follow the trend noticed in the case of adult females. The fraction of bullock labour hired out is substantially high (26% in the lowest size group of holdings (0-5 acres) (Annexure: Table 2).

Section II : Cost of Production of Crops

(a) *Factor-wise analysis of costs of Production of Rabi crops on cultivators' holdings,* 1959-60.—As in previous year, human and bullock labour resources, which are preponderant relative to land in smaller holdings, are more intensively used in contrast to holdings of larger size. Consequently, costs of cultivation per acre declined with increase in size of holdings. Unlike the previous year, however, the output per acre did not tend to decline with increase in size of holdings. (Annexure: Table 3).

(b) *Average Productivity of Land and Labour in principal rabi crops on Cultivators' holdings,* 1958-59.—In the lowest size-group of holdings, 70 per cent of the *rabi* acreage was under wheat and the remaining fraction was divided equally betwee

am and wheat plus gram mixture. The mixture fraction was less important in higher es where gram competed equally with wheat for *rabi* acreage. In regard to average oductivity of factors, optimal holding sizes indicated were: Wheat 5-10 acre; Gram id Wheat-gram mix: 10-15 acre. (Annexure: Table 4).

Section III : Agricultural Marketing : Milk and Ghi, 1959-60

With increase in size of holding, the strength of milk stock, the volume of milk oduced and the average productions of milk per head of milk stock tended to rise. igher holding was negatively correlated with the fractions of milk and ghi produced it were sold. While the fraction of fluid milk produced which was consumed as ch on the farm tended to be the same (40 to 43 per cent), the fraction diverted for oduction of ghi and the consumption of ghi instead of its sale rose as the size of ldings tended to rise (Annexure: Table 5).

Section IV : Agro-Economic Surveys

Analysis of ownership and operating units of cultivation in Selected villages in Intensive Cultivation Block attached to the I.A.R.I. (1959-60) showed the operating its exceeded those owned in the lowest size-group (0-5 acres) and were less in the gher sizes.

Size-Group of Holding (acres)	Operating units expressed as percentage of ownership units
— 5	124
—10	97
b—15	99
ver 15	94
ll	103

Group B: Research Projects Completed by Post-graduate students

Sri B. K. De completed his requirements for the M.Sc. degree in October, 1960. s thesis entitled "Input-Output relationship in cultivators' holdings in the Intensive ltivation Block" may be summarised as follows:

Subject to limitation of size of the sample, the findings indicated that farms low 5 acre size were unprofitable concerns. Those falling in 5-15 acre size range re optimal. Large scale mechanised farming was most profitable.

Capital investment had a direct and positive bearing on productivity of labour d capital used Labour productivity increased with increase in man-work units.

Crop enterprise sector of the farm business was apparently better organised than ilk enterprise. The latter invariably reduced profits or aggravated losses.

Yield per acre of wheat and *bajra*, number of man-work units per cropped acre and also per acre of operational holding bore positive relationship with net income of the farm."

Annexure

Table 1 : Average cost (Rs.) of maintenance of livestock on Cultivators' holdings, 1959-60.

	Size of holding (acres)	Ave. No. of heads of stock	Average annual cost per head		Average daily cost		Average annual cost on milk stock inclusive of dry stock per 100 seers of milk produced	
			Labour	Feed	Per holding	Per animal	Labour	Feed
Bullocks	0— 5	1·6	185·4	417·7	2·64	1·65		
	5—10	1·8	170·8	446·9	3·04	1·68		
	10—15	1·7	160·9	431·6	2·75	1·61		
	Over 15	2·5	169·6	479·2	4·44	1·77		
Milk stock	0— 5	1·8	216·6	452·0	3·29	1·82	26·34	54·97
	5—10	2·5	192·0	383·8	3·95	1·58	24·71	49·41
	10—15	2·5	119·2	541·6	3·50	1·40	13·82	45·54
	over 15	2·2	95·4	612·4	4·26	1·93	9·48	60·91

Table 2 : Percentage of available labour supply on farms allocated to different purpose 1959

M=adult males; W=adult females; C=children.

(a) **Human Labour**

Purpose	0—5 ac.			5—10 ac.			10—15 ac.			+15 acres		
	M	W	C	M	W	C	M	W	C	M	W	C
Crop production.	31·05	13·26	11·87	24·54	19·44	10·82	32·64	16·38	8·26	26·11	18·84	11·0
Maintenance of cattle.	26·97	19·84	22·17	22·14	18·69	13·22	24·89	18·44	12·96	17·81	20·39	13·1
Family & social engagements.	29·76	50·66	21·23	37·33	44·12	11·12	26·16	53·78	11·24	35·37	50·73	10·5
Sick and/or not gainfully employed.	12·22	16·24	44·73	15·99	17·75	64·84	16·31	11·40	67·34	20·71	10·04	65·9

(b) **Bullock Labour**

	0—5 ac.	5—10 ac.	10—15 ac.	+15 acres
rop production	40·5	59·6	67·7	73·7
ired out to others	26·2	7·9	5·7	4·8
ck and/or unemployed	33·3	32·5	26·6	21·5

able 3 : Factor-wise analysis of costs of Production (Rs.) per acre of principal rabi crops, 1959-60.

ze of holdings (acres)	Labour		Seed	Manures & fertilisers	Irrgn.	Land cost	Interest & deprecn.	Total cost	Grain yield per ac. Mds.	Cost of production per md. of grain
	Human	Bullock								
Wheat										
0— 5 . .	78·30	105·30	17·00	..	2·12	30·60	5·64	238·96	18·1	13·20
5—10 . .	60·62	99·45	12·60	5·80	2·12	27·18	5·59	213·36	18·3	11·65
0—15 . .	71·22	72·80	14·50	5·90	2·12	32·99	5·60	205·13	18·0	11·39
- 15 . .	64·95	50·50	17·90	2·00	2·12	29·68	3·66	170·81	18·2	9·38
Gram										
0— 5 . .	38·99	37·70	6·80	..	..	25·66	5·64	114·79	8·5	13·50
5—10 . .	58·60	44·85	7·10	..	..	24·61	5·59	114·95	8·7	13·18
0—15 . .	38·34	32·50	6·90	..	..	29·60	5·60	112·94	5·9	19·14
- 15 . .	29·92	21·60	7·90	..	..	31·07	3·66	94·15	6·4	14·17

able 4 : Average Value Productivity (Rs.) of Land and Labour in principal rabi crops on Farmers' holdings, 1958-59

PR = % of *rabi* average H. L. = human labour B. L. = Bullock pair labour

ze of lding cres)	Wheat				Gram				Wheat+Gram Mix.			
	P.R.	Land	H.L.	B.L.	P.R.	Land	H.L.	B.L.	P.R.	Land	H.L.	B.L.
0— 5 .	69·6	23·16	0·37	3·66	15·8	54·96	2·22	8·61	14·6	22·76	1·28	5·23
5—10 .	55·1	8·94	0·63	3·80	40·7	57·37	2·56	11·27	4·2	48·67	1·90	5·35
0—15 .	47·9	24·80	0·18	3·29	48·6	55·34	2·69	12·92	4·5	51·08	2·16	6·54
- 15 .	47·9	17·51	0·02	3·60	48·4	51·94	2·69	11·56	14·7	17·56	0·97	5·12

Table 5: Production and disposal of milk and ghi on farmers' holdings, 1959-60.

P—Production-milk in seers; ghi in chhataks.
C—Consumption by family
S—Sales

	0—5 acres			5—10 acres			10—15 acres			+ 15 acres		
	P	C	S	P	C	S	P	C	S	P	C	S
Milk												
Total .	1480	591	548	1944	840	307	2155	900	351	2213	918	197
% of P		39·9	37·0		43·2	15·8		41·8	16·3		41·4	8·9
Ghi												
Total .	555	451	104	1080	940	140	1064	1064	..	1180	1171	9
% of P		81·2	18·8		87·0	13·0		100	..		99·2	0·8

Agricultural Research sub-station of I.A.R.I. Karnal:

General.—The total area of sub-station is 305·98 acres. The areas cropped during *'Kharif'* 1960 and *Rabi* 1960-61 were 139·48 and 219·33 acres as compared with 236·36 and 234·28 acres during *Kharif* 1959 and *'Rabi'* 1959-60 respectively. The main activities of this Sub-station were :

(i) to conduct agronomic researches on various field crops; (ii) multiply and distribute seeds of improved strains of field crops; and (iii) render assistance to different Divisions of the Institute in carrying out (a) breeding for smut and bunt resistance of wheat (b) varietal-*cum*-date of sowing trial on wheat by Head, Botany Division, (c) wheat mutation trial by Head, Botany Division, (d) wheat varietal trial-barani and irrigated, (e) Barley varietal trial by Head, Botany Division, (f) Researches on pathology of red-rot and wilt of sugarcane, (g) Co-ordinated projects on fertilisers and soil-fertility with Soil Science and Agricultural Chemistry Division including Varietal-*cum*-manurial trial of wheat, (h) establishing a mango orchard for Horticulture Division.

Weather : The following table gives the average monthly maximum and minimum temperature in °C and total rainfall in cms. (along with departure from normal).

Average monthly Max. and Min. temperature and total rainfall

	Max. temp. °C		Min. temp. °C		Rainfall cms.	
	Average	D/N	Average	D/N	Total	D/N
July, 1960 . .	34·8	—1·7	26·5	+1·7	33·0	+15·2
Aug., 1960 . .	33·6	—1·8	25·3	+1·5	31·8	+17·0
Sept., 1960 . .	33·4	+0·3	23·4	+2·0	0·7	—13·1
Oct., 1960 . .	32·2	—1·0	18·2	—0·3	5·9	+5·5
Nov., 1960 . .	26·6	..	10·5	..	..	..
*Dec., 1960 . .	22·8	..	6·3	..	..	+0·4

(*Average upto 25th December, 1960).

The excessive rainfall and heavy downpour during July and August damaged the *Kharif* crops in general, inundated paddy crop, and maize for seed purposes. The dry month of September was also detrimental in poor setting of paddy grains as water could not be made available during the earing and grain formation stages.

During *Rabi* 1960-61, the dry and rainless months of November and December, 1960 caused droughty conditions and it is likely to have an adverse effect on the growth of wheat crop.

Research Projects:

(A) *Manurial Experiments*

(i) *Cultural-cum-fertiliser experiment on Maize (Modified) (Varieties×Dates of sowing×spacing×doses of N).*—This was the first year of the experiment. The treatments consisted of the following: 2 Varieties, 2 dates of sowing, 3 spacings, 3 N levels.

Due to heavy and incessant downpour of monsoon rainfall from 2nd July 1960 the sowings of 15-7-1960 (D2) could not be done.

It is proposed to repeat the same experiment with changed programme of sowing dates as (D1)—15th June (D2) 1st July instead of (D1) 1st July and (D2)—15th July as the monsoons start early in first week of July which makes the sowings impossible later than first week of July.

However, the indication given by the first date of sowing (1st July, 1960) with respect to different treatments on the average yield of maize grain is given in the following table:

Average Yield of Maize Grain in Md./Acre

Varieties	md./acre
V1-Texas 26	12·03 'F'test sig. —1%
V2-KT.41	15·79 SEm ±0·35
	CD.5% 1·04
	1% 1·44

Treatments		md./acre
Ndoses		
No—Nil		9·50
N1	50 lb. N	14·22
N2	100 lb. N	17·82
S.E.m		±0·48
C.D.—5%		1·43
	1%	1·97

Spacings.	md./acre
S1—24″×9″	18·64
S2—24″×12″	11·50
S3—30″×12″	11·25
SEm±0·50	
CD5% 1·46	
CD 1% 1·98	

The result indicates that variety K.T. 41 was significantly superior to Texas 26. Spacing 24″×9″ out-yielded the other two spacings and 100 lb. N dose yielded significantly higher than 50 lb. N which in turn was significantly superior to control. Interactions V×S, N×S and V×N were found to be significant. Thus variety K.T. 41 with a spacing of 24″×9″ and 100 lb. N dose produced the highest yield.

(ii) *Transplanting of wheat Experiment.*—(Varieties × dates of sowing in nursery × age of transplanting × doses of N): This is the second year of the experiment. The scheduled sowings and transplantings have been done. The transplanting shall be extended upto 2nd January as per treatments. The result shall follow in the next report.

(iii) *Tillage of wheat in conjunction with manures and fertilisers.*—This is the 5th year of the experiment. Sowings have been completed as per schedule. The results shall follow in the next report.

(iv) *6-acre cultivators' Holdings.*—There are four, six-acre cultivators' holdings experiments with different intensity of cropping, rotations and fertilizer schedules. The results will be reported after the harvest of *Rabi* crops.

(B) *Experiments in collaboration with other Divisions*

(i) *Phosphobacterin experiment on paddy: Kharif* 1960:

Treatment:

A—Untreated, B—Sulphate of ammonia (N), C—Sulphate of ammonia plus superphosphate.

D—Phosphobacterin, E—Sulphate of ammonia plus phosphobacterin.

F—Sulphate of ammonia plus Bonemeal, G—Sulphate of ammonia plus Bonemeal plus Phosphobacterin.

Treatments A to G further given a basal dressing of $2\frac{1}{2}$ tons of FYM/acre.

H—Sulphate of Ammonia.

I—Sulphate of ammonia plus phosphobacterin.

J—Sulphate of ammonia plus superphosphate.

K—Sulphate of ammonia plus Bonemeal.

L—Sulphate of ammonia plus Bonemeal plus phosphobacterin.

(No basal dressing of F.Y.M. from H. to L.)

Superphosphate or Bonemeal—40 lb. P_2O_5 per acre.

Superphosphate or Bonemeal—30 lb. P_2O_5 per acre.

Results:

Treatments	Yield of paddy md./acre
A	24·14
B	32·28
C	37·66
D	34·15
E	32·28
F	36·28
G	34·28
H	36·90
I	33·78
J	38·91
K	39·28
L	36·53
'F' test	Not significant
S. Em	±4·02

Phosphobacterin effects were not significant.

(ii) *Phosphobacterin Experiment on Maize.*—This was the second year of the experiment. The results for *'Kharif'* 1960 are given below :—

Treatments :

A—Basal dressing of F.Y.M. and Amm. Sulphate each to supply 30 lb. N.
B—Basal dressing plus phosphobacterin.
C—Basal dressing plus 60 lb. P_2O_5 as superphosphate.
D—Basal dressing plus 60 lb. P_2O_5 as superphos plus phosphobacterin.
E—Basal dressing plus 60 lb. P_2O_5 as Rock phosphate.
F—Basal dressing plus 60 lb. P_2O_5 as Rock Phosphate plus phosphobacterin.
G—Basal dressing plus 60 lb. P_2O_5 as Bonemeal.
H—Basal dressing plus 60 lb. P_2O_5 as Bonemeal plus phosphobacterin.
I—Ammonium sulphate at 30 lb. N plus phosphobacterin.
J—Ammonium sulphate at 30 lb. N per acre.
K—Phosphobacterin only.
L—Control (No manure, no phosphobacterin).

Results:

Treatments	Manurial effects	Yield Md/acre	Treatments	Phosphobacterin effects	Yield Md/acre
1	Basal manuring (A plus B) Super at 60 lb. P_2O_5.	14·74	With	phosphobacterin	16·08
2	(C plus D) plus basal manure . .	23·24	Without	phosphobacterin	16·03
3	Rock phosphate at 60 lb. P_2O_5 (E plus F) plus basal manure.	20·69	S. Em		± 0·33
4	Bonemeal at 60 lb. P_2O_5 (G and H) plus basal manure.	19·59			
5	Ammonium sulphate at 30 lb. N (I plus J)	14·26			
6	Control (No manure) (K plus L) .	3·84			

The data show that only manurial effects were significant. Superphosphate was found to be significantly superior to both rock phosphate and bonemeal which did not differ significantly between themselves. All the three forms of phosphate in combination with basal manure were significantly superior to basal manure alone. The difference between basal manure and ammonium sulphate at 30 lb. N. was not significant; however, both these were significantly superior to no manure(Control). Phosphobacterin effects were not significant. The interactions also were not significant.

Azotobacter trial on Paddy.—This was the first year of the experiment. The results during *'Kharif'* 1960 are given below :—

Treatments:

A—Control, B—FYM, C—Azotobacter (AZI) plus cellulose decomposing orgaisms, D—FYM plus Azotobacter (AZI) plus cellulose decomposing organisms.

E—Superphosphate.

F—Superphosphate plus Azotobacter (AZI) plus cellulose decomposing organisms, G—Azotobacter (AZ2) plus cellulose decomposing organisms, H—F.Y.M. plus Azotobacter (AZ2)+Cellulose decomposing organisms.

I—Superphosphate plus Azotobacter (AZ2) plus Cellulose decomposing organisms, J—F.Y.M. plus superphosphate plus Azotobacter (AZI) plus cellulose decomposing organisms, K—F.Y.M. plus superphosphate plus Azotobacter (AZ2) plus cellulose decomposing organisms, L—F.Y.M. plus superphos.

(AZI—Indian Strain; AZ2—Russian Strain).

Results :

Treatments	Yield Md/acre	Treatment	Yield Md/acre
A	12·84	I	16·85
B	15·03	J	18·56
C	15·03	K	18·56
D	19·30	L	14·17
E	18·56	S.Em	±1·86
F	14·29		
G	14·78		
H	16·00		

Azotobacter culture did not significantly increase the yield of paddy.

Assistance and facilities were given to the other Divisions of the Institute in carrying out their experiments during the period under report.

Seed Supply :

Crops	*Quantity of seed distributed*
Wheat	1269·85 mds.
Barley	1·05 mds.
Peas	45·65 mds.
Oats	12·08 mds.
Linseed	0·60 mds.

Agricultural Extension :

Research projects of 6 M.Sc. Extension (2nd year stage) and 2 Ph.D. Extension students (2nd year stage) continued during the period. The M.Sc. stage students completed their projects by August, 1960 while the Ph.D. Students are still continuing their projects.

The projects which were completed during the period under report along with their salient findings are given below :—

(i) *Relative influencing capacity of different agencies in pursuading rural youth to adopt improved farm practices.*—Out of the three leaders studied, youth leader proved best followed by the school teacher and village leader in getting improved practices accepted by youths.

The different age groups amongst youths did not show any significant differences in learning about improved practices; but the high income and education groups proved superior to low income and education groups.

The change in the attitude of youths about the practices is positively correlated with the change in attitude of parents.

(ii) *Relative effectiveness of extension techniques for popularising improved vegetable growing on the Intensive Cultivation Scheme area, Nangloi.*—Out of the three teaching tools tried, personal contact and result demonstration were found to be effective and were followed by group discussions in popularising vegetable growing. Age and size of holding were not found to be a barrier in the acceptance of improved practices, while educated cultivators responded better towards acceptance as compared to less educated farmers.

(iii) *Relative effectiveness of extension methods for popularising artificial insemination in villages.*—Out of the three extension tools "group discussions" was found to be most effective for popularising artificial insemination and was followed by personal contact and field trials. Age of the farmers had no substantial influence on the effectiveness of extension teaching while education and status of the farmers were positively correlated with effectiveness of teaching.

(iv) *Relative effectiveness of different number of exposures through extension methods in motivating milk producers of Intensive Cultivation Scheme area to organise milk selling Cooperative Societies.*—Eight exposures gave significantly superior results over 4 exposures irrespective of the method of the approach and socio-economic factors. Age group 31 to 45 years responded better to extension teaching than the older and the younger groups. Quality of milk sold, size of holding and family size have no relationship with change in attitude; knowledge and behaviour of the farmers about co-operatives.

(v) *Relative influence of Socio-economic factors on the acceptance of cow dung gas plant by the farmers when exposed to extension teaching.*—Age is not found to be associated with the acceptance of cow dung gas plant when other socio-economic factors are held constant. The different socio-economic factors behaved independently and no important interaction was found to be present between them. Maximum response of farmers was noticed at 4-6 exposure level. With increase in number of exposures the rate of increase in response was comparatively more in literate group than illiterate group. Even 9 exposures failed to bring about the acceptance of cow dung gas plant by farmers.

(vi) *Relative effects of method demonstration and flannelgraph on certain psychosocial characteristics among rural farmers towards the acceptance of improved practices.*—Schooling of farmers always proved effective with acceptance of practices. The levels of social status did not stand as barrier to the acceptance of innovations of farming. There was no consistent association between levels of age and acceptance of practices.

Practical Training.—One student from Netherlands was admitted for giving practical training in community development work. The student studied the working of community projects for 8 months and has left for his country.

Intensive Cultivation Scheme Area.—The various divisions co-operated in carrying out work in the Intensive Cultivation Scheme area and the following work was done during the period under report :

(a) Laying out of demonstration plots—319 (222 during *Kharif* and 97 during *Rabi*).
(b) Plant protection work & rat control—14 villages.
(c) Purchase of ammonium sulphate by farmers—322 mds.
(d) Planting of shady trees—2250.
(e) Planting of fruit trees—250.
(f) Ploughing weed infested area with soil inversion plough—582 acres.
(g) Dressing of seed with Agrosan GN—274 mds.
(h) Supply of improved seed to other States—Wheat 4950 mds.; Gram 200 mds.
(i) Meetings arranged—17.

Key Village Scheme.—The progress of work under the scheme is given below:—

(a) Cows served naturally	22
(b) Buffaloes served naturally	147
(c) Semen collected cow	18
(d) Semen collected buffalo	17
(e) Cows artificially inseminated	7
(f) Buffaloes artificially inseminated	22
(g) Cow calves born out of artificial insemination	2
(h) Buffalo calves born out of artificial insemination	11
(i) Cow calves born out of natural service	16
(j) Buffalo calves born out of natural service	69
(k) Calves registered under calf subsidy scheme	37
(l) Castrations performed	3
(m) Animals treated for various diseases	215
(n) Animals tested for pregnancy	48
(o) Inoculations carried out	2550
(p) Cattle fair held	1

With effect from October, 1960 the work on this subject was transferred to the newly opened Division of Agricultural Extension.

Programme of Work for 1961

1. *Soil Fertility Section :*
   (i) Building up of soil fertility through organic manures and inorganic fertilisers.
   (ii) Phosphate fertilisation of legumes.
   (iii) Rearing of pail-fed calves on skim milk, anti-biotic waste products and urea
   (iv) Experiments on mixed farming.

Field Crop Section :

(i) Response to manures and fertilisers.

(ii) Varietal and cultural trials.

(iii) Agronomic studies on grasses and legumes with special reference to their suitability for pasture management and development.

(iv) Grassland Scheme (I.C.A.R.).

Vegetable and Commercial Crops Section :

(i) Response to manures and fertilisers.

(ii) Cultural and Varietal trials.

(iii) Vegetable growers' two and half acre holdings.

Farm and Cattle Development Section :

(i) Line breeding and selection for improvement in milk yield.

(ii) Feeding of stock on balanced ration for optimum growth.

(iii) Rearing of pail-fed calves on skim milk, anti-biotic waste products and urea.

(iv) Mixed Farming Experiment.

(v) Intensive Cultivation Scheme and Key Village Scheme.

Projects under Third Five-Year Plan :

(i) Irrigation Investigations Scheme.

(ii) Weed control Investigations Scheme.

(iii) Plant Tissue Tests Spray Fertilisation Scheme.

Agronomic Experiments of Botanical Sub-Station, Pusa.

(i) Permanent Manurial and rotation experiment.

(ii) New Manurial Experiment.

All India Coordinated Scheme of Fertiliser Experiments.

(i) Model Agronomic Experiments.

(ii) Simple Fertiliser trials on cultivators' fields.

DIVISION OF AGRICULTURAL ENGINEERING

(SHRI E. G. K. RAO)

Supply of Drawings

10 Sets of blue prints of working drawings of agricultural implements and machines have been supplied on request to the following parties for facilitating their manufacture.

1. Dandakaranya Development Authority (4 sets).

(i) Paddy thresher

(ii) Paddy weeder

(iii) Rice Huller (Hand Operated)

(iv) Maize Sheller.

2. M/s. Kalinga Industries Ltd., Calcutta.
   (i) Hand operated Rice Huller.
   (ii) German chaff cutter
   (iii) Triphali
   (iv) Chinese plough
   (v) Dismantleable furniture
   (vi) Maize sheller.

Blue prints are supplied free to the government organisations whereas a nominal charge of Rs. 5 per set is made to the private parties.

Schemes

1. *MUSEUM OF AGRICULTURAL MACHINES AND IMPLEMENTS:*

The scheme is progressing satisfactorily. It attracts a large number of visitors every day. His Imperial Highness the Crown Prince of Japan paid a visit to the Museum on 2nd December, 1960. About 3550 visitors have visited the Museum.

2. *RESEARCH-CUM-TESTING CENTRE FOR BULLOCK DRIVEN AND MANUALLY OPERATED AGRICULTURAL IMPLEMENTS—IARI CENTRE:*

The scheme is in progress. Besides conducting the field trials of the Land-Master L-150 Tractor and Otto Universal Frame, the Centre has manufactured 60 Hand Hoes developed in this Division and six scythes of foreign design. At the instance of the I.C.A.R. a list of equipment required for each Research-*cum*-Testing Centre has been prepared and sent to them. A plan for the workshop building for the Centre has also been prepared.

3. *SURVEY OF ADDITIONAL INDIGENOUS AGRICULTURAL IMPLEMENTS :*

Due to the delay in the appointment of the Officer for the Scheme, there was little progress of this scheme during the last six months.

4. *PRODUCTION, DEMONSTRATION, TRIAL AND POPULARISATION OF IMPROVED AGRICULTURAL IMPLEMENTS :*

The work of compilation of the test reports is in progress.

Research

1. *BULLOCK-DRAWN SEED DRILL:*

The drum type bullock drawn seed drill which has been designed and developed in this Division and was reported in the last Annual Report was put into extensive field test during this period. During these tests it was found that the seed metering mechanism was not working properly and was giving irregular seed rate. Hence the design of the seed metering has now been modified and it is under further trials at present.

GROUNDNUT PLANTER:

After the successful completion of field trials of this machine at the Institute farms detailed working drawing of the machine has been prepared. A few of this machine now proposed to be manufactured by a private firm and the Director's sanction for this purpose has been obtained.

INVESTIGATION OF WATER LOGGING PROBLEM AT I.A.R.I.:

Water table observations were continued during the period at fortnightly intervals. Observations had also been taken in the cluster of three piezometers designed to find out the direction and gradient of flow of under-ground water by the application of a formulae derived by this Division. Data for the last 20 years have been processed through the use of this newly developed formulae in regard to the three unused wells 10-c and 14-c. Maximum Hydraulic Gradients and direction of flow have been worked out which are of great importance in the design of our drainage system. The H.G. showed a variety from 1.93 per cent to 6.78 per cent with the direction of flow varying from 25°—11′ N.W. to 86°—S.W.

TILE DRAINAGE PROJECT:

Piezometer tubes which had been installed earlier, were refixed after drilling holes through them as it was found that the data recorded previously did not conform to the expected behaviour of the water table curves. The average discharge of individual tiles was observed in order to determine their effectiveness.

The following table shows the discharge observed during the months of August, September and October, 1960 and it is evident from these figures that the under ground tile line system is working quite efficiently.

Discharge

Tile Line No.	Average Gallons per minute			Total for August, Sept. & October, 1960					
				Gallons			Cubic Feet		
	Aug.	Sept.	Oct.	Aug.	Sept.	Oct.	Aug.	Sept.	October
1/4	5·85	4·91	2·79	261000	212112	120528	41800	34000	19300
2/4	6·00	4·03	2·47	267840	174096	106704	42840	27900	17100
3/4	0·77	0·34	0·01	34400	14688	432	5500	23400	69
4/4	5·64	3·70	2·10	252000	259840	90720	40300	25600	14550
5/4	11·20	7·40	4·22	500000	319680	182304	80000	51200	29300
1/A	0·21	0·66	0·04	9360	28512	1728	1500	4570	277
2/A	3·13	1·49	0·14	139800	92880	6048	22380	14900	968
3/A	1·62	2·91	2·48	72200	125712	107136	11570	20200	17200
				1540600	1127520	615600	255890	201770	98764

MISCELLANEOUS

PARSHALL FLUME:

A few 3″ parshall flumes have been fabricated. A direct indicating type of flume being designed. This will enable to obtain direct readings of flows and if necessary

an automatic recording unit could also be attached. This would represent a marked improvement in existing design.

(ii) A demonstration of a bullock-drawn off-set disk harrow, a dibbler and a hand hoe developed in this Division was held in Director's presence in the Horticulture Division in July, 1960.

The disc harrow was developed with a view to evolve an implement for rapid seed-bed preparation with animal draft-power. During the demonstration, the harrow produced good tilth upto a depth of about 4"-5". The working width was about 30" and the draft 175-225 lbs. comparable to a mould board plow.

The dibbler incorporated on experimental seed metering and dropping mechanism for precision metering of seeds was developed in this Division. During the demonstration, the seed metering and dropping was found to be satisfactory. An application for obtaining patent on the mechanism has been submitted to the Director which will be filed with the patent office.

The hand hoe aims at providing an improved multipurpose hand tool for intercultural operations. It enables the worker to work in standing position which is adopted while working with Khurpi for the same work. It was demonstrated that the hoe could be used more conveniently and could remove weeds and leave the soil in pulverised condition upto a depth of about 2"—2½" and it could also uproot effectively small bushy growths. An application for the patent of this implement has since been filed with the Patent Office.

Programme of work for the year 1961-62

A: Research Projects completed and under extensive tests and trials:

1. Improvement of Olpad Thresher.
2. Development of a Bullock Operated Float.
3. Development of two-row groundnut planter.

B: Research Projects continuing from 1960-61:

1. Development of a bullock drawn seed-drill.
2. Development of a bullock drawn fertilizer placement machine.
3. Development of dibbler.
4. Development of a bullock gear.
5. Development of heating and lighting appliances for use with cow-dung ga plant.
6. Investigation on water-logging problems at IARI.
7. Tile drainage project.
8. Project of water measuring and allied devices.
9. Testing and standardization of agricultural implements and machines.
10. Development of animal drawn disk harrow.

Research Projects intended to be taken up during the year 1961-62:

1. Research on water lifting devices with financial assistance from Ford Foundation.
2. Research on methods of construction and lining of irrigation channels.
3. Soil conservation engineering, contour bunding of Todapur Block in the I. A. R. I.
4. Experimental Farm Structures *i.e.,* Green Houses etc.

DIVISION OF AGRICULTURAL EXTENSION

(SHRI A. R. KHAN)

With the appointment of the Head of the Division of Agricultural Extension (Shri A. R. Khan) in October, 1960, this newly formed Division started functioning.

Intensive Cultivation Scheme

(a) *Result Demonstrations :*

115 plots to demonstrate the efficiency of fertilisers, improved seeds, improved implements and better cultural practices were laid out during the period 1960-61.

(b) *Wheat Varieties :*

The new wheat varieties—NP 823 and 824 are being demonstrated. They have been reported to be higher yielders than the old variety NP 718 which is grown in bulk by the farmers of Scheme villages. The farmers have shown liking for the new varieties.

(c) *Introduction of berseem :*

Berseem as a fodder crop was introduced during the previous years and about 17 cultivators have taken it up this season. The farmers have appreciated its green forage and the demand is likely to increase further.

(d) *Supply of improved seed to the States :*

The scheme is serving a useful purpose for some years by supplying large quantities of improved seed especially of wheat to different states. During the current season about 10,000 mds. of NP 718 wheat and 800 mds. of NP 58 gram were supplied to the Agril. Dept. of West Bengal, Orissa and Kutch.

Key Village Scheme

The work of the Key Village Scheme continued during the period. Efforts are being made to popularise artificial insemination among the farmers. Regular supplies of semen are also made to the Veterinary Department, Delhi.

The eight cow dung gas plants installed in the I.C. Scheme area at farmers' houses are working satisfactorily. There is a demand for 2 more gas plants on 50:50 basis and necessary steps to meet the same are being taken.

Programme of work during 1961

The work will consist of (1) Research and (2) Teaching.

1. *Research and Development.*—The scope of operation will be enlarged by having all the Villages in Kanjhawala Block and not the 19 villages already under the scheme for the work of the Division. Research work will also be carried out on new items when the staff is in position. It is proposed to organise a programme of agricultural development in Kanjhawala Block by utilising the Extension techniques during 1961. The work of Key Village Scheme and Calf Subsidy Scheme will continue on the lines as in previous years.

2. *Teaching.*—Post-graduate training to M.Sc. and Ph.D. students in Extension will be given on larger scale from next session as it is hoped the Division will be fully staffed by that time.

DIVISION OF BOTANY

(DR. A. B. JOSHI)

The research activities of the Division continued under its four main sections: Plant Breeding and Genetics, Cytology and Cytogenetics, Crop Physiology, and Plant Introduction and Exploration. The primary objective of the investigations is the production of superior varieties of important economic plants. Basic investigations having a bearing on applied work were also in progress, and the recent establishment of a laboratory for fundamental plant genetical research in the Division constitutes a further step in this direction. Four projects were finally formulated for inclusion in the Third Five-Year Plan, which included the strengthening of the Plant Introduction and Exploration Organisation and also of the Central Seed Testing Laboratory, the construction of a Phytotron—an artificial "Climate house" for use in fundamental research, and the setting up of a full-fledged unit for the genetic improvement of essential oil yielding plants.

The Gamma Garden was formally inaugurated on the 26th August, 1960 by Shri S. K. Patil, Minister for Food and Agriculture. This facility, which will be available to all agricultural and biological scientists, constitutes a landmark in the country's progress towards the exploitation of atomic energy for agricultural improvement.

A brief account of the results obtained in the main lines of research is given below :—

Plant Breeding and Genetics

1. *Improvement of Indian Wheat :*

Extensive regional testing of the new rust resistant "N.P. 800 series" of wheats has shown that N.P. 824 is remarkably widely adaptable and has given very good performances over a major portion of the wheat-growing tracts in the country; N.P. 823 has done best in Delhi State and adjoining areas and N.P. 825 in Punjab. N.P. 829, which has performed consistently better than Ridley—an Australian wheat variety introduced by this Division and released for cultivation in the northern hills—in the

wer hills of northern India, was released for general cultivation. Uniform trials were d with these wheats, for the third year in succession, at 145 centres in the plains and centres in the hills, covering the States of Himachal Pradesh, Punjab, Rajasthan, ttar Pradesh, Bihar, West Bengal, Orissa, Madhya Pradesh, Gujarat, Maharashtra, ndhra Pradesh and Mysore. Another series comprising 8 new rust resistant strains bread wheat (*Triticum aestivum*), developed at the Indore Centre, is being tested 14 centres in the States of Madhya Pradesh and Rajasthan. As a result of breeding ork on hard wheat (*T. durum*) carried out at Indore, 10 black and brown rust resis- nt strains were given N.P. numbers and sent for large-scale field testing at 8 ntres in the States of Madhya Pradesh, Uttar Pradesh, Maharashtra and Andhra adesh.

Hybrid maize:

The work on the development of regionally suited flint-type hybrids of maize, ing conducted under the Coordinated Hybrid Maize Scheme financed by the Indian uncil of Agricultural Research, has reached an advanced stage of single cross testing d prediction of outstanding double-cross hybrids. About 45 elite inbred lines, origi- ing from indigenous and foreign sources, were put into 540 single-cross combina- ns and these were tested uniformly in 12 yield trials at 13 locations in India. From data obtained, 106 outstanding double crosses were predicted; seeds of these are ing produced for further extensive testing in the different maize-growing regions. e predicted yields of these double crosses range between 45 and 120 per cent. over local open-pollinated varieties included in the tests. These hybrids have flint-type ins, about the same maturity period as the local varieties, and a greater measure of sistance to the Indian diseases and pests of maize. The best four among these hybrids rived from crosses between inbred lines originating from germplasm from India, the S.A., Columbia and Peru, have beeen put into commercial production at Hyderabad ring the *rabi* season of 1960-61 and they will be ready for conducting demonstration als in farmers fields during the *kharif* of 1961. The parentage of these four hybrids :

(1) (Peru 330 × G. 715—1) × (Col. 1 × A. Theo)
(2) [P4A(Y) × P5PB5] × [G. 715—36 × P4 — 1 (B)]
(3) (Col. 1 × A. Theo) × (CI 21E × Nar. 330)
(4) (A. Theo × Peru 330) × (CI 21E × G. 715—1)

Bajra (Pennisetum typhoides):

The outstanding yield performance of the Improved Ghana type, the original ma- ial of which was introduced by this Division from Ghana, was confirmed by the als conducted at Delhi during the period under report. Improved Ghana gave a culated yield of 741 kg. per acre as compared to 605 kg. given by T. 55, a Punjab e which is grown widely in Delhi and adjoining areas. Improved Ghana is some- at earlier in flowering and maturity than T. 55 and has strikingly larger grains. Mass ection is being further carried out in the new type and it is proposed to conduct a demonstration trials with it in some Delhi villages during the *kharif* of 1961.

Grasses:

In a small-scale field test, the F_1 hybrid ($2n=21$) between cultivated *bajra* (*Pennisetum typhoides* $n=7$) and Elephant grass (*P. purpureum*, $n=14$) gave very

encouraging forage yield as compared to Elephant grass. The hybrid, which will be tested on a larger scale next season, is very vigorous and produces softer and more palatable leaves and is also superior to Elephant grass in respect of leafiness and protein content as would be seen from the following table :

	Forage yield (gm.) per plant (average of 15 plants) during the season		Leafiness %	Protein content %
	Fresh yield	Dry yield		
Elephant grass . .	177·2	35·5	56	4·1
F1(Bajra × Elephant grass) . . .	404·0	92·2	65	5·1

Another hybrid, between a strain (I.W. 1530) of *anjan* grass (*Cenchrus ciliaris* 2*n*=36) from Rajasthan and a strain (E.C. 5635) of *Pennisetum ciliare* (2*n*=36) from the U.S.A., has also given very high forage yield in a pilot test at Delhi. The hybrid, which is very leafy and produces softer leaves than the parents, has 2*n*=45 chromosomes and is pollen sterile, but it gives a good set of seeds apomictically and yields a uniform progeny. It shows most active growth during the spring season at which time both of its parents remain practically dormant. Fifteen clumps of the hybrid gave a total dry yield of 71 gm. as compared to only 22 gm. given by the better parent. Large scale tests will be carried out next season.

5. *Cotton:*

In the germplasm collection of *Gossypium hirsutum* maintained at this Division, S.A. 594 from the U.S.A. appeared to possess a remarkable boll bearing capacity, although it gives very low values in respect of boll size, seed weight, staple length and ginning out-turn. The F_1, F_2 and backcross progenies of the cross, H. 14 (the local standard) ×S. A. 594, were grown for a biometrical study during 1959. The results of analysis, which became available during the period under report, showed that the F_1 was considerably heterotic in respect of boll number, in the inheritance of which character complementary epistatic gene action appeared to be operative. Boll number and boll size did not seem to be correlated. Several promising selections have been made and grown during the *kharif* of 1960 to explore the possibility of combining high boll number with the other desirable economic attributes of H. 14.

6. *Vegetables:*

Promising strains, earlier in maturity and possessing long, shiny and attractive pods have been isolated in vegetable *guar* (*Cyamopsis tetragonoloba*) from the cross, *Pusa Sadabahar*×*Pusa Mausami*. Further progress has been made in the programme for incorporating the "closed-anther" mutant character into Pusa Purple Long with the ultimate object of facilitating hybrid brinjal seed production. This variety has shown excellent combining ability in hybrid combinations in respect of fruit yield. Similar work, for incorporating the male-sterility gene in the varieties Sioux, Pusa Ruby and Red Top of tomato has reached a still more advanced stage of completion.

Further reports have been received from almost all over the country regarding the remarkably outstanding performance of *Pusa Sawani*, a *bhindi* (*Abelmoschus esculentus*) variety bred in this Division which is completely free in the field from symptoms of the ravaging yellow-vein-mosaic disease and which gives higher yields than the earlier best variety, *Pusa Makhmali*. A sweet, edible podded variety of peas, Sylvia, introduced from Sweden has been released for distribution.

7. Seed Testing :

170 vegetable seed samples were tested for purity, germinability and moisture content—as a part of the programme for the laying down of seed standards for Indian conditions. The method of X-ray analysis of seeds, recently developed in some European countries, was tried on 16 among the important economic crop plants, including vegetables, and was found to be a quick and reliable method of testing.

8. *Algae :*

Interesting results were obtained in preliminary pot-experiments on the variety, N.P. 130 of paddy for studying the efficacy of the blue-green alga, *Tolypothrix tenuis*, as a source of biological nitrogen. Azotobacter, with and without the alga and with and without the application of phosphorus and molybdenum was included in the experiments. The alga appeared to be a superior source of biological nitrogen, as judged from grain yield of rice, as compared to Azotobacter, with or without P_2O_5 and Mo.

Cytology and Cytogenetics

1. Mutation breeding in wheat:

Twenty-five awned mutants of N.P. 799 and six of N.P. 809 were tested in yield trials at Delhi and Pusa. All the awned mutants of the former wheat in the test yielded as well or a little better than the parental strains, while the performance of those from N.P. 809 was variable. Judging from this and the previous year's results, one mutant strain of N.P. 799 has been given an N.P. number, N.P. 836, and it has been included in large-scale yield tests. As is well known, the Indian farmers, especially those in the plains, have a preference for awned (bearded) wheats.

2. Interspecific hybridisation in jute:

The F progeny of the cross between *Corchorus olitorius* (var. Chinsurah Green) and *C. capsularis* (J.R.C. 13) showed segregation of parental characters in respect of growth and vigour, branching habit, leaf length/breadth index and extent of serration, onset of flowering and capsule size and shape. Only about 60 per cent. survival was observed in the F_2 progeny. The observations were in conformity with those expected from a species cross showing cryptic structural differentiation in the chromosomes. As reported earlier, this species cross is one which is very difficult to obtain and it was secured by a technique of reciprocal grafting-*cum*-pollen irradiation.

3. Sorhgum :

An extensive world collection of *Sorghum* species was under study in this material; over 100 intra-specific and interspecific hybrids, at various levels of ploidy, have been obtained for cytogenetical studies—many of them for the first time. The study conducted so far has led to the identification and marking of each of the 10 chromosomes at the pachytene stage.

4. *Oryza:*

In a re-investigation of the interspecific F_1 hybrid, *Oryza sativa* × *O. australiensis,* using the technique of pachytene analysis, it was found that no true allosyndetic bivalents were formed as observed by earlier workers. This study, as well as that on other species hybrids in *Oryza,* has thrown a very interesting light on species differentiation and evolutionary inter-relationship in this genus.

5. *Autotetraploid berseem:*

Search for variation within the colchicine-induced antotetraploids of *berseem* (*Trifolium alexandrinum*) showed differences between strains in respect of regeneration and forage yield in the various cuttings. As would be seen from following table the tetraploid strains generally gave strikingly larger forage yield than the diploid in the first cutting, whereas in the second and subsequent cuttings the yields were as good as, or somewhat inferior to, the diploid, the total forage yield in some strains being as good or somewhat better than in the diploids. Further large-scale field tests are in progress.

Forage yield per plot (15.5*m.*×2.6*m.*) *in kg.*

Strain	First cutting	Second cutting	Third cutting	Mean of three cuttings per strain.
C—10 . . 2n	14·84	66·34	80·74	53·97
T—708 . . 4n	34·29	67·75	44·95	49·00
T—709A . . 4n	30·51	47·19	37·56	38·42
T—709B . . 4n	35·14	75·86	60·66	57·22
T—724 . . 4n	31·11	79·53	58·47	56·37
T—780B . . 4n	16·57	59·61	55·64	43·94

Crop Physiology

1. *Study of drought resistance in wheat:*

In a critical study on the varieties, Pb. C. 281 and N.P. 720, interesting trends were observed with regard to sugar content of stem and rate of yellowing of ear. The course of grain filling appeared to be characterised by two phases. In the first phase (during 3-4 weeks after anthesis), the effect of variety or water-treatment on the rate of increase of grain weight was not manifested. In the subsequent phase, however, the rates of increase in 100 grain weight and of grain weight per ear were lower under drought and the varietal differences in respect of these characters became manifested, Pb. C. 281 showed a higher sugar content in stem and a slower rate of yellowing of ear. It therefore appeared that maximum sugar content of the stem (some time after dehiscence) was correlated with 1000-grain weight.

In another study the grain number per ear, under normal water supply and under intermittent drought from anthesis onwards, was examined in relation to flower number per ear and the role of protein synthesis on this character. Although in the first three of the four varieties, N.P. 798, N.P. 826, N.P. 823 and Ridley, grain number per ear seemed to be largely determined by flower number in the ear, it was not so in Ridley. Percentage of grain setting was the highest in N.P. 823, although it was similar

to Ridley in flowers per ear. In view of the fact that relatively higher concentration of soluble nitrogen was found in the ears of varieties in which grain setting was less, it appears possible that either this factor, or some toxic catabolic product engendered under drought in the leaves, acts adversely upon grain setting.

2. *Plant hormones:*

In a field experiment with the cotton variety, 216F, spraying with beta-naphthoxy-acetic acid (5 and 10 p.p.m. with wetting agent), about 6 weeks after sowing, did not increase the yield of seed cotton, in contrast with the positive results reported last year.

Plant Introduction and Exploration

1. *New Collections:*

1112 samples of seed and other planting material were introduced from abroad and 803 samples collected within the country. Important among the new introductions were : genetic stocks of wheat from the U.S.A. and Mexico and of barley from the U.S.A., Israel, and East Germany; a sweet potato variety from the Fiji Islands reported to be weevil resistant; high tannin strain of *Rumex hymenosepalus*; a runner type of paddy from the Philippines; *sesamum* species and varieties from Japan; *Medicago* and *Trifolium* strains and several horticultural plants, including *Monodora tenuifolia, Memecylon coeruleum, Engenia grandi* and *Flacourtia jangomes,* from Australia. Extensive collections were made during a survey of the far flung districts of Himachal Pradesh.

2. *Evaluation:*

Among the recently introduced material, E.C. 4211 of cowpea appeared to be an early-maturing type, very suitable for fodder *cum*-grain yield. A grain-type of cowpea from Russia appeared to be earlier in maturity and superior in yield to Branco, the previous best introduced variety recommended for general cultivation; it seemed to be promising as a summer crop. An extremely early-maturing type of tomato, flowering in 4 weeks after transplantation, was obtained from Russia. Several Australian Soybean varieties have appeared to be high yielding and they possess the non-shattering character of pods. A South American type of grain chenopod, *Chenopodium quinoa,* appears very promising in view of its better yield than local varieties, earlier maturity and superior grain setting. A species of grain amaranth (*Amaranthus montegazzianus*) from the Argentine seems to possess a considerable measure of resistance to the shoot borer, which commonly ravages grain amaranths in India.

Botanical Sub-station, Pusa

Experimental work directed towards the maintenance, multiplication and testing of improved varieties and other materials needed in the breeding programmes received maximum attention. The crop plants whose seeds were sown for maintenance or multiplication included wheat, rice, gram, oats, linseed, *urid,* lentil, *rahar,* jute, *Hibiscus,* etc. The wheat varieties included in the multiplication plots were N.P. 710, N.P. 758, N.P. 761, and N.P. 798. Nearly 164 mds. of seed of N.P. varieties of wheat and other crops, multiplied during the previous year, was distributed mostly to State Departments of Agriculture.

Evaluation of available varieties of several crop plants was in progress; trials had been laid with 8 varieties of fodder oats, 6 varieties of *urid* (*Phaseolus mungo*) including 4 N.P. varieties, 12 varieties of *rahar* (*Cajanus cajan*), two diploid and autotetraploid varieties of *toria* (*Brassica campastris* Var. *toria*), 4 N.P. varieties of chillis, 6 improved varieties of brinjals (*Solanum melongena*), 8 early and 12 medium maturing varieties of peas, and 12 tomato varieties including some extracted from the cross Sioux x Dickson. Results were available from the yield test conducted with four *urid* varieties N.P. 4, N.P. 6, N.P. 7, N.P. 14, *Kandhar mash* and local. N.P. 14 in giving the highest yield confirmed its superior performance of past years.

Programme of work for the Year 1961

1. Improvement of Indian wheats with special reference to breeding varieties for different agronomical conditions.
2. Genetics of rust resistance and other characters in wheat.
3. Study of the suitability of N.P. wheats and other breeding material to different agronomical conditions.
4. Study of the milling, baking and *chapati* making qualities of Indian wheats.
5. Breeding for rust and smut resistance in barley.
6. Breeding for rust resistance and earliness in linseed and wilt resistance and earliness in pigeon-pea (*Rahar*).
7. Breeding extra-long staple varieties of cotton.
8. Trials with the recently evolved N.P. strains of crop plants in the different states of India.
9. Trials with foreign varieties, foreign and indigenous inbreds and hybrids of maize on a regional basis in India.
10. Investigations on the utilisation of hybrid vigour in various crop plants including maize, *jowar, bajra,* onion, *bhindi,* radish, tomato, bringal and cotton.
11. Breeding for high yield and early ripening in fodder and grain types of *jowar* and *bajra.*
12. Breeding of some pasture grasses and legumes for northern India, with special reference to suitability to arid, semi-arid and hill regions.
13. Study of the wild relatives of crop plants and their utilisation in plant breeding.
14. Improvement of chilli, with special reference to the breeding of disease resistant varieties.
15. Improvement of some essential oil bearing plants, *e.g.,* cumin, dill, fennel, coriander and carum.
16. Breeding of vegetables, including the European type vegetables such as cabbage, cauliflower, turnip, etc. and development of improved methods for the commercial production of quality seed in them.
17. Testing and certification of seeds of vegetables crops.
18. Improvement of ornamental plants by the application of modern techniques like induction of polyploidy and mutations.

19. Study of the genetic variability in Indian algae with a view to their usefulness to agriculture.
20. Induction and study of polypoidy as a method of crop improvement of oleiferous Brassicae, linseed, berseem etc.
21. Cytogenetical studies in various crop plants, including cotton, oilseeds and millets.
22. Monosomic analysis of rust resistance and other characters in wheat.
23. Cyto-taxonomical and cyto-ecological studies in some Indian fodder grasses.
24. Induction of mutations in crop plants through the use of chemicals and radiations from radio-active isotopes, neutrons, X-rays and ultra-violet rays.
25. Studies on the incidence and induction of pollen sterility in crop plants.
26. Application of embryo culture technique to overcome embryo lethality in distant crosses.
27. Improvement of cytological techniques.
28. Study of radiation dose fractionation effect on chromosome aberrations in barley.
29. Investigations on relationship between nucleolar and DNA synthesis in chromosomes.
30. Differential mutability of genes with various mutagenic agents.
31. Fundamental and applied studies on distant hybridisation in economic plants.
32. Cytogenetical studies in tomato, barley etc. with particular reference to detection of compound loci and experimental control of recombination.
33. Studies on genetic control of self-incompatibility in plants.
34. Physiological studies on resistance to drought and lodging.
35. Physiological analysis of factors concerned with yield in wheat.
36. Influence of light and temperature on growth and development in wheat.
37. Physiological aspects of plant nutrition in wheat—studies on the relation between varietal differences in the uptake of nutrients.
38. Plant hormones—investigations on their role in growth and development in wheat, cotton, etc. and their use as weedicides.
39. Plant Physiological studies in relation to the die-back disease of citrus.
40. Plant Physiological studies on colchicine induced autopolyploids of oil-yielding plants, such as *toria,* linseed, etc.
41. Plant introduction and exploration for indigenous plants of economic value; their maintenance, evaluation and trials at Delhi and other places.
42. Multiplication and distribution of the pure seeds of improved N.P. varieties of field and vegetable crops.
43. Inheritance studies on chemical differences determining quality in economic plants.

DIVISION OF ENTOMOLOGY

(DR. E. S. NARAYANAN)

A. *CHECK LIST OF INDIAN INSECTS*

Five hundred and sixty five species of Indian Sphecoidea were listed in the check-list of Indian insects under preparation. Four hundred and ninety-three species of Carabidae and 400 species of Noctuidae were added to this check list.

B. *DONATIONS*

Forty specimens of Cerambycidae were presented to His Imperial Highness, the Crown Prince of Japan on his visit to the Institute. Three hundred and thirty two specimens of insect pests belonging to different orders were donated to different institutions, colleges and State Departments of India.

C. *NATIONAL PUSA COLLECTION*

The proper maintenance of the National Pusa Collection was continued with the timely application of the preservatives and periodic cleaning of the specimens. During the period under report, 1,692 insect store boxes, 162 jars containing wet collection of insects and 20 show cases of main identified collection of Hymenoptera were replenished with fresh preservatives.

Fourteen slides of fleas, 39 specimens belonging to 20 different species of Braconidae and 18 specimens belonging to 8 different species of Embioptera were received as donation to the National Pusa Collection.

D. *RESEARCH*

1. *Taxonomy:*

Taxonomic studies on Indian Noctuidae (Lepidoptera) and Carabidae (Coleoptera) were taken up.

In the studies on the Indian Sphecoidea, 3336 specimens from various parts of India were examined. These comprised 296 species falling under 41 genera of which 3 genera were not so far recorded from this country. Keys for the separation of these genera and for the identification of the species within each genus have also been drawn up.

2. *Insect Parasitology:*

Studies were taken up to investigate how different foods affect the fecundity of *Chelonus rufus* Lyle, an egg-larval parasite of *Earias* sp. and *Laphygma exigua* Hbn. The different feeds studied were : sucrose, glucose, fructose, maltose, sorbitol, mannitol, raisin, honey, tap-water and distilled water. It was observed that the various sugars, polyhydric alcohols (sorbitol and mannitol), honey and raisin all increased the fecundity considerably. While a single fertilized female laid on an average 35.00, 42.00 and 55.33 eggs, without food and water, with tap water and with distilled water respectively; as many as 173.16, 183.33 and 261.00 eggs were laid by a fertilized female when fed with maltose, fructose and honey, respectively. Adult feeding was reflected in the length of oviposition period also. The oviposition period on an average was 14.00, 14.33, 14.83 and 18.66 days with fructose, raisin, maltose and honey respectively, as against 3.50, 3.66 and 4.16 day with distilled water, no food

and water, and tap water respectively. The increase in the length of the oviposition period was, in turn, correlated with longevity of the females when fed with different foods. Females lived for 17.00, 17:16, 19.66 days on an average when fed with raisin, maltose and honey respectively; and for 4:33, 4:16 and 5:16 days without food and water, with distilled water and with tap water respectively. Females lived longer than males under all conditions. All the experiments were conducted at a constant temperature of 27° C± 1 and 70% relative humidity.

Studies were also undertaken to investigate the effect of temperature and humidity on the fecundity of *C. rufus*. The experiments were conducted at 15°C, 20°C, 25°C, 30° C, 35° C and 40° C, with four relative humidities namely, 45%, 60%, 70% and 90%. Experiments were conducted at various combinations of these temperatures and humidities. These experiments revealed that temperature had a statistically significant effect on fecundity, whereas the effect of humidity or of the interaction of temperature and humidity was not statistically significant.

3. *Section of Insect Ecology and Toxicology:*

In the control schedule for cotton, four sprayings were carried out with different insecticides, namely, 0.1% *gamma* BHC, 0.05% endrin, 0.05% diazinon, 0·25% sevin and a mixture containing 0.025% *gamma* BHC+0.0125% endrin+0.0125% diazinon+ 0.0125% parathion. The data are being statistically analysed.

The experiment on the control schedule for maize was completed for the fourth year. In all two sprayings were given and the average yield of maize in different treatments per plot of 900 sq. ft. was found to be, for parathion+DDT mixture–24.6 lbs., *gamma* BHC–21.5 lbs., DDT–20 lbs., endrin–19.3 lbs., and control–13 lbs.

Maize seeds were treated with lindane at a rate of 20 lbs./100 lbs. of seeds (which is approximately 2.5 lbs./acre). The seedlings from treated seeds were found to be toxic to the first stage larvae of *Chilo zonellus* upto 20 days after sowing; the next lower dose of 10 lbs./100 lbs. was found to be effective for a less period. Some phytotoxicity was also observed in the seedlings.

Fifteen insecticides were tested against the sugarcane mite *Schizotetranychus* sp. and eight insecticides against the hoppers and the adults of *Locusta migratoria*. 2.5% BHC dust was found to be effective against nymphs of Phadka upto 17 days, when applied to the soil at a rate of 80 lbs./acre.

Ecological studies on Phadka were continued. The eggs of Phadka remained viable upto three years. The freshly emerged nymphs remained confined to the sides of bunds and mounds for about a fortnight.

Viability of paddy seeds (variety N.P.13), stored since April 1959, at 30° and 60% R.H. was considerably decreased, by 60–75%, while those stored at 30° C and under room temperature ranging between 13° to 39° C at 30% R.H., it was 70–90%.

Second Five-Year Plan Schemes

(1) *Entomological investigations with the help of radioactive isotopes:*

When the first instar nymphs of *Dysdercus koenigii* F. were irradiated for 24 hours with *beta* radiation from P^{32} sources giving dosages of 0.5, 1, 2, 4 and 5 per hour

it was observed that the percentage of successful completion of development of the pest upto 2 generations was adversely affected in 5r hour dose as compared to other dosages and control.

(2) *Biological testing and certification of insecticides:*

Bioassay of different insecticides was carried out against crop pests *Aphis craccivora, Eutetranychus bombsi* and a predator *Stethorus* sp. Three samples of *neem* cake extract, received from the Chemistry Division, I.A.R.I. and one chemical received from the National Rayon Corporation, were tested for insecticidal properties. Further, a sample of 10% BHC dust reported to be phytotoxic to paddy crop in Andhra Pradesh was tested.

Experiments were conducted on the separate and joint action of DDT, parathion and phosdrin, using adults of *T. castaneum* as test insects.

(3) *Storage Pest Ecology:*

It was found that wheat could be stored in good condition from May to October in alkathene lined earthen storage structures. Experiments on the effect of CO_2, on the development of *Trogoderma* were continued. Preliminary experiments carried out on the development of *Calandra oryzae* in air-tight storage of rice, showed that there was no development and the adults lived for 5, 17 and 26 days at 25° C in rice, having a moisture content of 10, 12 and 14% respectively. Similar work on *Trogoderma* was in progress.

(4) *Seed Testing:*

Fifty samples of vegetable seeds such as beans, pea, cabbage cauliflower, brinjal, lady's finger, tinda, pumpkin and bottle gourd collected from the Punjab and U.P. were tested. The tested samples were either free from the damage by pests or the damage was caused to them by the pests in the field, in the store or both in the field and the store. The pests recovered from seeds in stores were, *Rhizopertha dominica* in pumpkin, *Stegobium* sp. in tomato and *Trogoderma granarium* in bottle gourd. The maximum percentage of damaged seeds in the tested samples ranged from 3.0 to 49.3. The highest damage (49.3%) was in pea by *Bruchus pisorum* which attacks the crop at the time of seed formation. The cucurbit seeds were also damaged by rats in stores and the damage in them ranged from 3.7 to 16.7 per cent.

(5) *Scheme on Locust Toxicology:*

Efforts were continued to segregate a lindane resistant strain of the desert locust. Metabolism of DDT in the desert locust was being studied by paper chromatographic and alumina column techniques. Studies on the fecundity of females reared on different semi-synthetic diets and on the viability of eggs laid by them, were in progress.

(6) *Indian Honey Bee Scheme:*

Management of colonies during the summer-monsoon dearth period of July-August showed that maintenance of adequate stores was necessary for successful summering. Studies on pedigree breeding showed that early queen rearing during November-December was hampered by unsuccessful mating of queens; only 30-40% queens mated successfully this year.

(7) *Insect Physiology Scheme:*

Field data were collected regarding the behaviour of several varieties of sorghum and corn in relation to the damage caused by *Chilo zonellus.*

A new research project on resistance in mustard and allied crops for aphids was started.

Studies on Insect microbiology and symbiosis.—It was demonstrated conclusively that in *Leptocorisa varicornis,* a serious pest of paddy, microbes were present in the gut epithelium and that they find their way into lumen of the gut from time to time. Male organs did not seem to play any role in the transmission of symbiotes.

Studies on Dysdercus koenigii.—Dysdercus, a pest of cotton had been shown to need "cotton seed" fractions. It was possible to replace cotton-seeds, at least partially by a mixture of extracts made by ether, acetone, alcohol and chloroform. Further details were awaited.

(8) *Scheme for the Survey of Beneficial Parasites:*

Out of a number of parasites collected or reared, four were first records of different genera namely, *Praon* spp. (Braconidae), *Leptomastix* sp. (Braconidae), *Stephanodes* sp. (Mymaridae) and *Maidliella* sp. (Mymaridae).

Studies on predatory and other mites were continued. A new species of the genus *Melichares* (*Blattisocius*) Keegan was described. Four species of mites, three predatory and one phytophagous, were observed to be associated with the malformation in mango trees. The predatory species were *Typhlodromus rhenanus* (Oudeman), *T. nesbitti* (Womersley) (Phytoseiidae) and *Cheletogenes ornatus* (Canestrini and Fanzaga) (Chelytidae) while the phytophagous species was *Aceria mangiferae* (Sayed) (Eriophyidae). Of these 4 species, only *C. ornatus* had been recorded earlier from India; the other three were new records.

I.C.A.R. Schemes

(1) *Biology and control of termites infesting the agricultural crops*:

The field experiments (i) on the control of termites infesting wheat under unirrigated conditions and (ii) on the varietal resistance of wheat to termite attack were laid in a randomised plot design.

(2) *Exploration of toxicity hazards in the use of modern insecticides against cattle and human beings :*

Benzene hexachloride to the extent of 2.4 p.p.m. was recovered from the peripheral grains stored in double layered jute bags and dusted with 5% BHC dust at a rate of 6 oz./100 sq. ft. There was no residue of DDT and BHC dust on peas after 14 days of treatment while in the case of sprays the residues were 0.25 p.p.m. and 0.23 p.p.m. for DDT and BHC respectively. Similar studies were carried out with tomatoes. No lindane was translocated in 'bhindi' plants, when the insecticide was applied on the soil surface even at as high a dose as 122.4 lb./acre. Further, no difference in the recovery of insecticidal residues was observed when chopped and ground samples of treated maize plants were taken.

(3) *Nutritional and Biological studies of insects* :

While rearing *Chilo zonellus* efforts were made to investigate the nature of nutrients in yeast and "leaf factor" by replacing these by pure substances including vitamin, B-complex and a variety of maize "Ill. 1656" respectively.

Investigations have been undertaken to study the role of graded dosage of micronutrients in *Trogoderma granarium.*

Sitophilus oryzae was taken as a test insect to find out the role of certain vitamins on growth and metamorphosis and survival potential of immature stages.

PROGRAMME OF WORK DURING 1961.

Section of Parasitology:

1. Host selection and distribution of progeny in *Chelonus rufus* Lyle.
2. Host selection and distribution of progeny in *Bracon chinensis* Szep. and *B. brevicornis* Wesm.
3. Studies on coefficient of parasite efficiency of some parasites of cotton bollworm and the root, stem and top borers of sugarcane.
4. Biological control of pink bollworm (*Pectinophora gossypiella* Saunders) by means of its parasites *Apanteles angaleti* Muesebeck and *Bracon brevicornis* Wesm.
5. Biological control of potato tuber moth infesting potato in storage.
6. Studies on chalcid egg parasites of *Pyrilla perpusilla* Walk.
7. *Scheme under the Second Five-Year Plan* :
   - (i) Studies on the biology and bionomics of insect parasites and predators.
   - (ii) Fundamental studies in insect parasitism.
   - (iii) Studies on Indian Scelionidae.
   - (iv) Studies on Indian Eulophidae.
   - (v) Studies on Indian Mymaridae.
   - (vi) Survey and collection of beneficial parasites and predators in the Indian Union.
   - (vii) Mass breeding of hosts and beneficial parasites.

Section of Insect Ecology and Toxicology:

1. Studies on the development and distribution of insects under different ecological conditions.
2. Studies on population determination and assessment of damage.
3. Effect of chemical control on the biological balance of cultivated crops.
4. Factors responsible for variation in the susceptibility of insects and the toxicity of insecticides.
5. Bioassay of fumigants.
6. Studies on the effect of contact insecticides (DDT, BHC, Dieldrin) and fumigants (CS_2, HCN and Chlorosol) on the insect infestation in stored grains and the viability of seeds.

7. Field and laboratory tests with pyrethrins against important crop and stored grain pests.
8. Laboratory tests on the chemical control of the Desert Locust in flight and *in situ*.
9. Oviposition response by the Desert Locust.
10. Phenological observations on crop pests.
11. Plant Introduction.
12. *Schemes under the Second Five Year Plan:*
    (i) Entomological investigations with the help of radioactive isotopes.
    (ii) Biological testing and certification of insecticides.
    (iii) Ecological studies on the insect pests of stored grain.
    (iv) Testing and certification of improved varieties of seeds.
    (v) Bee-keeping.
    (vi) Locust toxicology.

Section of Systematic Entomology:

1. Taxonomy of Indian Curculionidae (Coleoptera).
2. Taxonomy of Indian Aeshnidae (Odonata).
3. Studies on Indian Ichneumonidae (Hymenoptera).
4. Review of the Chalcididae (Hymenoptera).
5. Taxonomy of Indian Tenebrionidae (Coleoptera).
6. Studies on *Lasioderma serricorne*.
7. Studies on Indian Sphegidae (Hymenoptera).
8. Studies on Indian Tingidae (Heteroptera).
9. Studies on Noctuidae (Lepidoptera).

Section of Insect Physiology (Scheme under the Second Five-Year Plan):

1. Plant Breeding for resistance to insect pests.
2. Nutrition of insect associated with stored plant products.
3. Rearing of beneficial insects including parasites in artificial diet.
4. Symbiosis and its physiological significance.
5. Digestive physiology of insects.

I.C.A.R. Schemes:

1. Termite Research Scheme. (The Scheme is discontinued w.e.f. 1st of April, 1961).
2. Toxicity hazards of modern organic insecticides to human beings and cattle.
3. Nutritional and biological studies on the insects of agricultural importance.

DIVISION OF HORTICULTURE

(DR. G. S. RANDHAWA)

The salient features of the results achieved, during the six months period, are briefly summarised.

A. RESEARCH

1. *FRUIT SECTION* :

(1) *Collection.*—Fifty seven species and varieties of *Citrus* have been collected from Patiala, Pathankot, Saharanpur, Coorg and Assam and also from California, Mexico, Australia and Malaya.

(2) *Mango.*—Detailed studies on the different varieties of mango revealed interesting variations in fruit characters, of three varieties Dasheh'. Langra and Chausa. Further studies will be made in the next seasons.

(3) *Citrus.*—(i) *Taxonomical studies:* Eighty specimens of bark samples of different species and varieties, were subjected to colorimetric tests with different reagents, as a part of taxonomical investigations.

(ii) *Propagation trials.*—The rooting behaviour of hardwood cuttings of sweet lime was studied, using different plant regulators singly and in different mixtures. The percentage of survival under different treatments is given in the accompanying table.

Plant regulator	Concentrations		
	2500 ppm	2000 ppm	1500 ppm
IBA	46·7	41·7	65·0
IAA	48·3	46·7	43·3
NAA	16·7	60·0	43·3
IBA+IAA	50·0	48·3	76·7
IAA+NAA	73·3	43·3	31·7
NAA+IBA	35·0	53·3	55·0
Control	36·7	..	..

The above data reveal that except NAA at 2500 ppm. other treatments have enhanced the survival percentage over the control. The mixture of IAA plus IBA at 1500 ppm. gave the highest percentage of survival.

(iii) *Studies on fruit drop.*—Plant regulator sprays, at blooming time failed to arrest the June drop in sweet orange varieties. However, the preharvest drop was checked by sprays during the month of October. In Jaffa and in Mosambi varieties, 2, 4, 5-T at 30 ppm., was effective while in Pineapple variety 2, 4-D at 15 ppm. was efficacious. Dipping of fruits in plant regulator solutions gave some interesting results. In Ioppa variety, the preharvest drop was minimum in the treatment with 2, 4-D 500 ppm. (2.5%), followed by 2, 4, 5-T 500 ppm. (5%). Maturity of fruits was accelerated in the treatment with MH 2500 ppm. while the other treatments *viz.*, 2, 4-D and 2, 4, 5-T, delayed the fruit maturity and ripening.

(iv) *Floral biological studies.*—All the varities of lemon except Hill lemon flowered almost throughout the year, with two main flowering seasons in February to April and other in August to September, under Delhi conditions. Hill lemon and rough lemon flowered only once in a year. The proportion of perfect flowers was low (15 to 19%) in Columbia, Genoa, Seedless and Turanj Citron while in Malta it was quite high (69·84%). In Malta lemon variety, the fruit-set was markedly higher

when the flowers were cross-pollinated than when self pollinated. The observations suggested a certain degree of self incompatibility in this variety. The somatic chromosome number of varieties, namely, Nepali Oblong and Malta, was determined as $2n=18$. Meiotic preparations of Malta, Genoa, Nepali Oblong and Seedless Lemon showed nine bivalents.

(4) *Guava.—Propagation trials:* The performance of guava air layers in different media, was studied. The percentage of rooting and growth of roots recorded are given below :—

Treatment	Rooting percentage	Number of roots per air layer	Length of the longest root (cm)	Diameter of roots (cm)	Fresh wt. of root per layer
Sphagnum moss . . .	75	3·4	62·5	1·75	0·31
Vermiculite	80	4·1	38·2	1·55	0·19
Potting mixture	70	4·9	58·2	1·97	0·53

The sphagnum moss induced early rooting, but gave lower rooting percentage compared to vermiculite. The root growth was found superior in potting mixture compared to other media.

Investigations were conducted on the T budding in guava varieties. The month of April was found to be the optimum time for *Chittidar* variety while for *Safeda* variety March budding proved superior. The treatment with IBA (at 1 ppm) enhanced the percentage of success in the bud-take. Similar favourable results were obtained in the trials of guava air layers, using IBA. In this case IBA at 250 ppm was found to be very effective.

(5) *Phalsa.*—Propagation studies with hard and semi-hardwood cuttings showed that the last week of July would be the ideal time for planting. Similarly, for producing air layers, July was found to be the favourable month. The results obtained with the use of plant regulators in the production of air layers, are given in the following table.

Treatments	*July* Average no. of roots	*July* Average length of the longest roots in mm.	*July* Length × no. of roots	*August* Average no. of roots	*August* Average length of the longest root in mm.	*August* Length × no. of roots
Control . . .	6·77	69·75	472·70	9·20	58·87	541·60
IBA (25 ppm) . .	9·00	69·75	627·75	9·17	62·65	574·50
IBA (50 ppm) . .	5·90	57·75	340·72	7·55	43·00	324·65

The results reveal that July prepared layers produced greater number of roots and IBA at 25 ppm has given the highest number of roots.

2. *VEGETABLE SECTION:*

(1) *Tomato.*—An exotic variety, has shown high resistance to root knot nematode and further studies were under progress to confirm the findings.

Hybrid vigour.—Investigations with seven commercial varieties as parents, were conducted and thirteen F_1 crosses were studied for the manifestation of hybrid vigour. Early yields were high in hybrids and the average of the hybrids exceeded that of the parents by 162 per cent. Highest increase of 358.66 per cent in early yield over the better parent was shown by the cross between Local×Marglobe. As regards total yield of fruits, the average increase in the hybrids was of the order 47 per cent. Improved Meeruti×Local gave the highest increase of 55.18 per cent over the better parent. The cost of hybrid seed production was found to be compensated by an increase in yield of 0·5 per cent only.

(2) *Brinjal.—Inheritance of characters and their linkages* : The characters studied were pigmentation on vegetative parts, petal colour, fruit colour, pigmentation on stigma, habit of growth, spinescence, clustering habit of inflorescence, fruit shape and size. Linkage was noted between the genes for dark purple plant colour and violet petal colour and violet fruit colour. Linkage was also observed between genes for purple stripes on the anthers and purple fruit colour and violet colour of corolla and purple pigmentation on fruit stalk.

(3) *Cucumber.*—An indigenous variety from West Bengal, showed good performance and high field resistance to mildew.

Studies on sex expression and sex ratio.—The previous findings that plant regulators especially maleic hydrazide (MH), naphthaleneacetic acid (NAA) and gibberellic acid (GA) can induce earlier and more number of female flowers, were confirmed. GA at 10 ppm. induced giant ovaries, which developed into parthenocarpic fruits at a quicker rate.

Treatment		Number of female flowers per plant	Fruitset per plant	Final number of fruits per plant	Final yield fruits per plant in gms
MH	25 ppm	9·25	3·23	1·99	144·83
	50 ppm	9·66	3·50	2·33	158·08
	100 ppm	9·99	3·95	2·25	152·08
	200 ppm	11·22	3·74	2·16	152·99
	400 ppm	6·83	4·14	1·83	125·91
	600 ppm	6·99	4·58	1·66	113·41
NAA	50 ppm	11·74	2·89	2·47	163·33
	100 ppm	11·35	4·12	3·16	218·29
	150 ppm	8·33	4·42	3·08	207·49
	200 ppm	7·44	4·39	2·83	183·91
IAA	50 ppm	10·08	4·60	2·83	172·24
	100 ppm	6·66	5·30	1·99	132·24
2, 4-D	2·5 ppm	7·75	3·21	2·16	148·99
	5·0 ppm	8·08	4·03	2·33	150·24
GA	10 ppm	10·66	4·30	2·99	245·91
	25 ppm	9·83	4·19	2·66	214·66

Treatment	Number of female flowers	Fruites	Final number of fruits per plant	Final yield fruit per plant
GA 50 ppm	9·16	3·01	2·58	207·08
100 ppm	6·08	4·34	2·24	178·83
Removal of male flowers . . .	6·49	3·27	1·91	123·26
Water (control)	5·83	2·67	1·57	95·24
SE	±1·35	±0·46	±0·28	±19·57
C.D. at 1%	3·80	0·92	0·79	56·48

3. *FRUIT AND VEGETABLE PRESERVATION SECTION:*

A survey has been undertaken to study the problems of *murabba* manufacture.

(1) *Canning of fruits and vegetables.—Litchi* : Tests after about seven months of storage, showed that *Bedana* and *Dehraduni* varieties from Saharanpur were good canners. *Longia* variety from Muzaffarpur was not satisfactory.

Peas.—Of the 14 varieties of peas tested with regard to their canning quality, Bonneville, Early Giant, Yates Early Crop, Duke of Albany, Early Badger, N.P. 29, Little Marvel and Early Perfection, all picked at a reasonably tender stage of maturity, gave promising results during 8 to 9 months of storage tests based on consumer acceptability of the canned product in respect of colour, appearance, texture and flavour etc. The first four of these promising varieties were in general graded as superior to the rest.

Green beans.—Out of six varieties of green beans canned in brine at Katrain, during 1959 season, Giant Stringless 5843, Giant Stringless and Kentucky Wonder, gave promising results as good canners. These and five other varieties were continued to be under storage tests for further screening.

(2) *Drying and dehydration of fruits and vegetables.*—Peas : Sulphitation of peas after blanching prior to dehydration was found to improve the storage behaviour of the dehydrated products. Immersion for 30 minutes in a 0·25 per cent solution of potassium metabisulphite gave desirable results. Of the seven varieties, Duke of Albany, Bonneville, N.P. 29, Early Giant and T. 19 gave dried product of satisfactory quality. Rehydration by soaking in water before cooking was, however, found to be necessary for satisfactory results.

Onions.—Dehydrated onions of good appearance and white colour, though rather sweet in taste, were obtained by sulphitation and shredded vegetable in potassium metabisulphite solution prior to dehydration. The dried product could be converted into a powder of satisfactory quality. Further studies were in progress.

(3) *Indian preserves.—Apple* : Investigations carried out in collaboration with local *murabba* manufacturers, have revealed that *Ambri* variety was the most commonly used and sour apples did not give satisfactory product. Browning of peeled fruit before blanching can be effectively overcome by steeping in a 2.5 per cent salt solution containing 400 ppm. SO_2. Water blanching results in leaching out 15 to 50 per cent of soluble solids of the fruit. Fermentation of the preserve was found to have important role in checking the growth of proteolytic moulds.

(4) *Fruit juices and beverages.—Mandarin juice* : With a view to minimizing deterioration in the flavour of processed mandarin juice, varietal trials were initiated with three varieties, and studies were under progress.

In preliminary studies, freezing of juice at —18°C gave best results with regard to retention of Vitamin C, colour, odour and taste, Canned juice was the next best method of preserving the juice, and chemical preservation was not suitable. Three strains of mould and two of yeast were isolated from spoiled juice for use as test organisms, in a study of the efficacy of different chemical preservatives.

Fortification with vitamin C.—Orange squash and juice, mango squash and pulp, pineapple squash, apple juice and tomato juice fortified with vitamin C at different levels by adding synthetic ascorbic acid and *amla* extract (in case of three squashes only) separately, were under storage tests. From the studies it is seen that *amla* extracts in general helped in better retention of vitamin C, but adversely affected the colour, while synthetic ascorbic acid in general had no adverse effect on colour.

4. *CO-ORDINATED SCHEME FOR THE IMPROVEMENT OF WATERMELON AND MUSKMELON :*

In the pre-varietal trials, with sixteen cultures of watermelon, it was seen that a local variety was equivalent with exotic types like Rhode Island Red, Fukan Mudirigó, as regards yield. In muskmelon it was noted that IC. 3548, a collection from Delhi Market recorded the maximum outturn, while IC. 5138, was good in respect of quality characteristics like, sugar percentage, flesh thickness etc.

5. *CO-ORDINATED SCHEME ON FLORICULTURE :*

Roses.—During the period under report, new rose varieties were introduced from United Kingdom and West Germany. From U.K. 84 varieties of H.T. class, 8 of Floribundas, 4 of Miniature types and 15 of Climbing class were obtained. From West Germany, 45 varieties were received. The total number of varieties in the National Rose collection rose to 756 up to the end of this year. Among the new varieties introduced, Hawaii, Covergirl, Gold Crown, Piccadilly, Astree, Kleopatra in Hybrid Teas, Rumba, Flamenco, Doctor Faust, Allgold and Golden Delight in Floribunda class, and Solo, High Noon and Crimson Shower in Climbing types, are worthy of mention.

6. *VEGETABLE BREEDING SUB-STATION KATRAIN :*

French bean.—Four varieties of bush French beans, namely EC, 8148, EC. 1906 (wax podded) Contender and EC. 5843 were tested in a replicated row trial along with the control variety, Giant Stringless. The data presented below indicate that the variety Contender gave the highest yield of green pods with an increase of 102·23 per cent

over the control variety, while the variety EC. 8146 was the best in seed yield per plant.

Variety	Average yield of green pods per plant	Percentage increase over the control	Average yield of seeds per plant	Percentage of increase over the control
	ozs.		ozs.	
EC. 146	6·33	57·46	0·76	38·18
EC. 1906	5·51	37·06	0·58	5·45
Contender	8·13	102·23	0·69	25·45
EC. 5843	3·79	..	0·64	16·36
Giant Stringless (Control)	4·02	..	0·55	..

The variety Contender has emerged as a dual purpose variety, of good quality and high yield.

B. ADVISORY

Over 4500 rose plants of choice varieties have been raised during the last budding season and were distributed to 250 indentors of Delhi and other parts of the country. Besides, several garden enthusiasts were advised regarding the lay-out of rose beds, planting pruning etc.

Three Fruit Preservation factories were advised about their technical problems.

Programme of Work—1961

I. *Fruit Section :*

1. Survey, collection and evaluation of superior germplasm in tree fruits.
2. Performance of sub-tropical and tropical fruit species and varieties under Delhi conditions.
3. Improvement of grapes through hybridization with special reference to earliness, yield and fruit quality.
4. Induction and utilization of polyploidy for the improvement of grapes with special reference to seedlessness and other desirable qualities.
5. Improvement of mango by selection and hybridization.
6. Improvement of guava by selection and hybridization with special reference to yield and fruit quality.
7. Studies on morphology, floral biology and cytology of pomegranate with special reference to problem of sterility.
8. Induction of mutations in tree fruits through X-rays and radioactive isotopes.
9. Studies on blossom biology and sex ratio in mango.
10. Taxonomical studies in tree fruits: (a) mango (b) citrus and (c) other fruits,
11. Propagation studies in tree fruits: (a) citrus (b) guava (c) mango (d) phalsa.

12. Standardization of rootstocks in citrus.
13. Standardization of rootstocks in mango.
14. Plant regulator studies in tree fruits: (a) guava (b) grape.
15. Survey and collection of garden tools and implements from different States and their improvement.
16. Studies on biennial bearing in mango.
17. Manurial trial in mango (at Karnal).
18. Improvement of papaya by breeding with a view to evolve superior table varieties.
19. Breeding of temperate fruit varieties suitable for sub-tropical conditions : (a) apple (b) peach and (c) plum.
20. Improvement of small fruits by selection and hybridization : (a) strawberry; (b) cape gooseberry.

II. *Vegetable Section :*

1. Survey and collection of cultivated and wild species and varieties of both indigenous and exotic vegetables and assessment of variability in them and their utilization for breeding.
2. Breeding early, midseason and late varieties and varieties resistant to insect pests and diseases.
3. Studies on sex-ratio in cucurbits.
4. Studies on the pollination with special reference to insect pollinators. (In co-ordination with Entomology Division).
5. Studies on intra-sterile and inter-fertile lines in early cauliflower.
6. Studies on the inheritance of characters and their linkages in brinjal and tomato.
7. Studies on hybrid vigour in the following :
   (i) brinjal. (ii) tomato. (iii) cucurbits.
8. Studies on seed production with regard to yield and quality of certain summer and winter vegetables [cauliflower, radish, carrot and palak (*Beta vulgaris*)].
9. Studies on the chemical induction of male-sterility, suppression of male flowers and forcing up of female flowers in cucurbits.
10. Studies on the effect of plant regulators in the destruction or interruption of apical dominance in cowpea.
11. Studies on the effects of plant regulator sprays on fruit-set. (i) tomato.

III. *Fruit and Vegetable Preservation Section :*

1. Survey of fruit preservation industry.
2. Varietal trials on canning of fruits and vegetables: (a) green peas (b) litchi (c) beans (d) tomato (e) bhindi (f) mango and (g) oranges.

3. Investigations on Indian preserves (a) apple preserve (b) *amla.*
4. Investigations on drying and dehydration of fruits and vegetables (a) litchi; (b) carrot; (c) onions; (d) ginger.
5. Investigations on pickles and chutneys : (a) mango.
6. Investigations on fruit and vegetable beverages (a) phalsa (b) *jaman* (c) apple and (d) orange.

IV. *Co-ordinated Scheme for the Improvement of Muskmelon and Watermelon Delhi Centre :*

1. Pure line selection in watermelon and muskmelon.
2. Preliminary yield trials.
3. Intervarietal hybridization.
4. Production of seedless watermelons.

V. *Co-ordinated Scheme on Floriculture :*

1. Performance studies of different rose varieties introduced.

VI. *Vegetable Breeding Sub-station, Katrain :*

1. Study of varietal collection in different vegetable crops.
2. Evolution of inbred lines and study of their general and specific combining ability in cabbage, turnip and knol khol.
3. Evolution of intra-sterile and inter-fertile lines in cabbage, turnip and knol khol for hybrid seed production.
4. Breeding early, midseason and late varieties of vegetable crops : (i) Intervarietal crosses between the Asiatic and temperate varieties of turnip will be studied to breed early varieties. (ii) In carrot intervarietal crosses between Asiatic and temperate varieties will be studied with the same object.
5. (i) To find out optimum spacing in carrot to get the highest seed yield.
   (ii) Intervarietal crosses in cucumber will be studied, to improve the seediness.
   (iii) In-breeding work in carrot (Nantes) turnip (Golden Ball) will be continued to improve their flesh and core colour in carrot.
   (iv) In-breeding in two Capsicum varieties California Wonder and Yolo Wonder to breed pure lines.
6. Production of nucleus seed in the cross pollinated crops will be continued.

DIVISION OF MYCOLOGY AND PLANT PATHOLOGY

(DR. R. S. VASUDEVA)

A. Section of Plant Pathology

I. *WHEAT* (*Triticum aestivum* L.)

(a) *Rust* [*Puccinia graminis tritici* (Pers.) Erikss. & Henn., *P. triticina* Erikss. and *P. glumarum* (Schm.) Erikss. & Henn.].—Two hundred and two field collections of black and brown rusts, obtained from different parts of the country, were analysed for the study of physiologic races, and races 14, 15, 15-C, 17, 21, 21-A, 24, 34, 40, 42, 42-B, 53 and 117 of black rust and races 162, 107, 10, 20, 77, 106, 63, 17, 11, 26, 108 and 131 of brown rust were met with. Race 40 of black rust and race 162 of brown

rust were most prevalent. A new race of brown rust, resembling race 16 of the International Register, was found in the collections from Nilgiri hills to which *Agra local* wheat shows resistance.

In the study to determine the role of alternate hosts in the perpetuation of rusts, one of the common types of aecia found on *Berberis lycium* in the Simla hills has been shown to belong to *Puccinia brachypodii,* with its uredinial stage restricted to Brachypodium; no infection being produced on wheat, barley or oats.

In the seedling resistance tests, out of forty-three ND(58) wheat cultures, five proved to be resistant to all the thirteen races of brown rust. Tested with yellow rust, none of these 18 wheat cultures proved to be resistant. Fifty-six varieties were tested with a mixture of black rust races and 17 were found to be resistant.

Inoculum of physiologic races of the three wheat rusts was supplied to different wheat breeders and plant pathologists in the States on request.

(*b*) *Loose Smut* [*Ustilago tritici* (Pers.) Rostr.].—One hundred and sixty-six wheat varieties, inoculated last year, were sown for observations on disease incidence. In connection with the studies of physiologic races, 13 differential hosts inoculated with ten isolates were sown at Delhi and Solan.

(*c*) *Karnal Bunt* [*Neovossia indica* (Mitra) Mundkur] and Hill Bunts [*Tilletia caries* (DC) Tul. and *T. foetida* (Wallr.) Liro].—One hundred and forty-six varieties of wheat have been sown in pots at Delhi; 99 in the field at Karnal; and 44 in the field at Kangra for varietal resistance tests against Karnal bunt. In cultural studies, addition of Thiamine to the medium resulted in excellent growth of the bunt fungus. Addition of 0.25 gm. per litre of KCl to the basal medium also resulted in satisfactory growth.

Eighty-seven wheat varieties artificially infected with the spores of *Tilletia foetida* were sown for field tests at Simla in 7 randomized replications. In the field tests carried out at Himachal Government Farm, Shilaroo, 45 exotic wheat varieties alongwith one N.P. wheat as control were treated in one case with *T. foetida* and in other with *T. caries* and sown. Another lot of 32 exotic wheats was sown at Solan. Sowings have also been made in connection with the study of physiologic races. In host range studies, out of a total of 22 grasses inoculated with spores of *T. foetida,* bunt infection could be traced in *Lolium perenne* in late coming tillers, in addition to 6 species of *Aegilops* already reported.

2. *BARLEY* (*Hordeum vulgare* L.) :

(*a*) *Rust* [*Puccinia graminis tritici* (Pers.) Erikss. & Henn., *P. glumarum* (Schm.) Erikss. and Henn. and *P. hordei* Otth.].—Two field collections of black rust studied during this period did not yield any new race. In seedling resistance tests, 39 barley cultures from Simla were inoculated with a mixture of yellow rust races and 11 cultures found to be resistant. Tests with individual races are in progress. E. B. 47, E. B. 410 and N. P. 4 were found to be resistant to race G. With black rust 15 varieties were tested with a mixture of races and five with each race separately but none was found to be resistant.

3. *JOWAR* (*Sorghum vulgare* Pers.) :

Grain smut [*Sphacelotheca sorghi* (Link) Clint.].—In the varietal resistance tests with 47 varieties which were sown in pots and kept in laboratory at 22-29° C and later transplanted in the field, 31 have shown infection.

4. *SUGARCANE* (*Saccharum officinarum* L.) :

(*a*) *Red Rot* (*Colletotrichum falcatum* Went).—About 26 canes of each of the 94 varieties have been inoculated with the two cultures of *C. falcatum* by nodal infection method and 182 varieties by the standard plug method. In addition, 12 varieties which were found promising in the previous years' tests have been again inoculated by the plug method. Physiologic forms studies are in progress with 29 different isolates using 10 standard cane varieties.

(*b*) *Smut* (*Ustilago scitaminea* Syd.).—In the varietal resistance tests, 112 cane varieties at Karnal and 74 at Delhi were tested. Out of these, 74 at Karnal and 35 at Delhi have shown smut infection.

(*c*) *Rust* [*Puccinia kuehnii* (Krueger) Butler].—Five rust collections obtained from different places have been established for the study of physiologic races. In collateral hosts study, *Erianthus fulvus* rust produced resistant type reaction on Co. S. 510 and failed to infect *Erianthus munja*. The rust from the latter, however, infected *Saccharum barberi*.

5. *LINSEED* (*Linum usitatissimum* L.) :

Rust [*Melampsora lini* (Pers.) Lev.].—All the five races are being maintained in a viable condition. In physiologic race study 41 rust cultures from different States yielded races I_1, I_3, I_4 and I_5. In varietal resistance tests four varieties, *viz.* RR 415, RR 501, RR 279-B and RR 9 proved to be resistant to all the races. About 75 cultures have been established from the 'selfed' aecial material for further studies. Initial outbreak of the rust has again been observed through pycnial and aecial stages in the Kangra hills, and teliospores retain their viability in the hills through summer.

6. *PIGEONPEA* [*Cajanus cajan* (L.) Millsp.] :

Wilt (*Fusarium udum* Butler).—All the 20 varieties under test for wilt resistance got infected in the pot experiments, whereas in the field trials only 14 of them showed wilt symptoms.

7. *ANTIBIOSIS* :

Fifteen isolates of *Bacillus subtilis* exposed to various dosages of gamma rays were assayed for production of the antibiotic 'Bulbiformin' using *Alternaria tenuis* as the test organism. A few strains out of the irradiated isolates produced 3-4 times the antibiotic as compared to the un-irradiated control.

8. *PHYSIOLOGY OF FUNGI* :

Pathogenicity of *p*-aminobenzoic—less mutant of *Colletotrichum falcatum* which is almost non-pathogenic could be increased by supplying this vitamin to the soil. Isolate 78 of this fungus which does not grow on a minimal medium, shows good growth when the medium is supplemented with filtrate of isolate 244 from 15 days old cultures on the same medium, indicating thereby that substances required by isolate 78 for growth are synthesised by isolate 244.

9. *EFFECT OF ATOMIC RADIATIONS ON MICRO-ORGANISMS :*

A number of biochemical mutants of *Colletotrichum falcatum* were screened on Dextrose-Nitrate-Phosphate medium from cultures irradiated at initial activity levels of 181.52 and 272.28 mc/ml. Out of these, three cultures were found to be of extreme type and further work is in progress to find out the exact nature of deficiency.

10. *FUNGICIDES :*

Three new compounds, *viz.,* cyml mercury acetate, cyml mercury chloride, and dicyml mercury acetate were tested for their comparative fungicidal properties with *Alternaria tenuis* as the test organism. No. 1 was found to be the best and was active even at 1 ppm concentration. On comparison it proved to be as good as phenyl mercury acetate.

Comparative field trials with nine seed-dressing fungicides for the control of angular leaf spot of cotton (*Xanthomonas malvacearum*) showed that 2% ceresan improved germination, reduced the incidence of disease and increased the yield of cotton. Satisfactory results were obtained with spray fungicides in the control of anthracnose of cotton and with seed-dressing fungicides against grain smut of *Jowar.*

11. *SEED TESTING AND PLANT INTRODUCTION :*

Seed microflora of common vegetables continued to be studied and species of *Alternaria, Aspergillus, Fusarium* and *Rhizopus* were found to be chiefly predominant.

In connection with Plant Introduction Project, over 1697 seed samples of different crops received from foreign countries or intended for export were examined for ecto-or endo-phytic fungal flora and suitably treated with fungicides for surface disinfection and necessary phytosanitary certificates were issued. Some samples had to be rejected as these were found to be infected with pathogenic organisms.

12. *ASSESSMENT OF LOSSES DUE TO PLANT DISEASES :*

Field experiments to assess the losses due to *Helminthosporium* blight of maize, groundnut mosaic, angular leaf spot of cotton and potato mild mosaic are in progress.

13. *MISCELLANEOUS :*

(*a*) *Downy mildew of Maize* [*Sclerospora philippinensis* Weston].—'Kans' grass, *Saccharum spontaneum,* has been shown to harbour the same downy mildew fungus as maize and has, therefore, proved to be a collateral host.

(*b*) *Green-ear disease of Bajra* [*Sclerospora graminicola* (Sacc.) Schroet.].—In green-ear sick plot the disease did not appear on *bajra* crop unlike previous years. These plots were flooded with water for more than 10 days and this might have inactivated the oospores lying in the soil.

(*c*) *Foot-rot of Wheat* (*Helminthosporium sativum*).—*Helminthosporium sativum* culture filtrate was found to contain a toxic substance which inhibited the root elongation of wheat seedlings. The optimum temperature for the maximum production of toxin, which was thermostable, was found to be around 25
diseased roots was effective in inhibiting the root growth.

(*d*) *Nematodes in relation to plant diseases.*—Nursery seedlings of tomato in Horticulture Division and *Bhindi* plants in Botany Division were found to be affected with *Meloidogyne* spp. Artificially inoculated with nematode, the sugarcane plants showed poor development of root system as compared to healthy plants.

B. Section of Plant Bacteriology

A serious blight disease of sesamum was found to be caused by a bacterium and is under study. Another bacterium has been isolated from apricot cankers observed in Kulu Valley. A survey of maize crop in the Institute revealed the presence of bacterial soft rot caused by *Erwinia carotovora* in different maize cultures. In every case the infection was associated with stem borer attack.

C. Section of Plant Viruses

14. *SESAMUM* (*Sesamum orientale* L.) :

Phyllody.—The virus was successfully transmitted to *Centaurea moschata, C. cyanus, Medicago arborea* and *Oxalis* sp. through viruliferous jassids (*Deltocephalus* sp.). In the varietal resistance tests, sesamum varieties T. 4, T. 10, T. 12 and T. S. 2A-18 were found to be susceptible to the disease.

15. *PAPAYA* (*Carica papaya* L.) :

Mosaic.—The leaf extracts of *Carica cauliflora* were found to have inhibitory effect on the papaya mosaic virus.

16. *BANANA* (*Musa sapientum L.*) :

Mosaic.—The virus was successfully transmitted to cowpea var. New Era, French bean (*Phaseolus vulgaris* L.), *Solanum nigrum, Solanum jasminoides, Datura inoxia, Commelina benghalensis, C. nodiflora* and *Beta vulgaris* through the vector, *Aphis gossypii* Glov.

17. *MANGO* (*Mangifera indica* L.) :

Malformation.—The disease has been successfully reproduced with eriophyid mites collected from diseased as well as apparently healthy mango shoots.

18. *CITRUS* (*Citrus* spp.) :

'Decline' disease.—Calamandin orange and Mandarin Beauty were found to be infected with tristeza virus in nature when tested through *Toxoptera citricidus* on Kagzi lime and Key lime.

19. *TEMPERATE FRUITS* :

Apple mosaic was transmitted to apple variety Granny Smith. Apple variety Baldwin was found to be naturally affected with mosaic in Kulu Valley.

20. *VEGETABLE CROPS* :

Mosaic in brinjal has been found to be caused by at least five different viruses one of which is transmitted by aphids, while others are juice transmissible. Brinjal 'little leaf' virus was successfully transmitted to *Solanum sodomacum* and *S. indicum*. A virus causing mosaic in vegetable marrow was found to be sap-transmissible to vegetable marrow and tobacco.

21. *DEVELOPMENT OF NEW STRAINS, SEROLOGICAL RELATIONSHIP AND CROSS-IMMUNITY STUDIES :*

An antiserum was prepared for the bottle gourd mosaic virus and its antigenicity was established by precipitin test.

22. *ISOLATION AND PURIFICATION OF PLANT VIRUSES AND STUDY OF THEIR PROPERTIES :*

The viruses causing tobacco mosaic, *Dolichos* enation mosaic, Southern sannhemp mosaic and Delhi strain of sannhemp mosaic were isolated and purified.

23. *VIRUS-VECTOR RELATIONSHIP :*

The minimum acquisition feeding period required for the 'little leaf' virus of brinjal by the leaf-hopper vector, *Eutettix phycitis,* was found to be 10 minutes and the virus was retained by the vector for over 40 days. A single jassid, *Peregrinus maidis,* could transmit the chlorosis of *jowar* and the virus was carried by the vector in a persistent manner. The minimum acquisition feeding period required by the white fly, *Bemisia tabaci,* to transmit the yellow-vein mosaic of *Malvastrum coromandelianum* was found to be 30 minutes and the virus was carried in the insect vector in a persistent manner.

24. *DIRECT MEASURES OF CONTROL :*

In the experiments on the chemotherapeutic control of 'chirke' virus of large cardamom, thiouracil at the concentration of 0.1% as a soil drench for four weeks at weekly intervals was found to have beneficial effect and the treated plants remained apparently healthy.

25. *GENERAL :*

Host range studies were continued on *Dolichos* enation mosaic, beet purple leaf, pea mosaic, yellow-vein mosaic of pumpkin and yellow-vein mosaic of *Malvastrum coromandelianum*. Sterility disease of pigeon-pea was transmitted by an eriophyid mite. Mosaic diseases of mulberry and Passiflora were transmitted by sap inoculation. The virus causing chlorosis of *jowar* was transmitted to *Pennisetum purpureum* var. Thick, *Saccharum officinarum, Canna indica* and *Erianthus* sp. through the leaf-hopper vector, *Peregrinus maidis*. Mosaic of *guar* was transmitted by juice inoculation, and *Myzus persicae* and *Aphis medicaginis* proved to be its vectors. Mottle disease of sweet potato and mosaic of *Amorphophallus campanulatus* were transmitted by *Myzus persicae*. Two distinct virus diseases of groundnut have been collected and their virus nature established.

D. Section of Systematic Mycology

26. *TAXONOMY :*

Like earlier years, the emphasis was laid on the study of plant parasitic fungi.

(*a*) *Plant Pathogenic Fungi.—Phomopsis citri* on *Citrus* sp. and *Phyllosticta* sp. on *Pyrus communis* were recorded in India. Studies on the genus *Cerospora* were in progress, and 3 new species and 9 new host records were reported. *Cercospora sorghi* on *Zea mays* was also recorded in India.

(*b*) *Entomogenous Fungi.—Aspergillus parasiticus* on *mosquito, Acremonium* sp. and *Sporotrichum* sp. on aphids were recorded in India.

(*c*) *Group studies.*—(i) *Ascomycetes* : Some noteworthy ascomycetes newly recorded in India include: *Capnodium salicinum* (A. & S.) Ell. and Ever. on *Quercus incana; Microsphaera alni* (Wallr.) Salmon on *Viburnum cortinifolium; Lophium* sp. on *Hedera helix; Phomatospora* sp. on *Coffea arabica.*

(ii) *Basidiomycetes* : *Exobasidium brevieri* Bond on Fern, *Angiopsora* sp. on *Artemesia* sp., and *Calophyllum* sp. and *Cerotelium* sp. on *Flacourtia* sp. were found to be new records for India.

(iii) *Fungi Imperfecti* : *Stigmina quercina* (Wakefield) M. B. Ellis on *Quercus incana; Chaetopeltis laurina* (Tassi) Sacc. on *Berberis* sp.; *Stauronema sacchari* Syd. & Butler on *Musa* sp.; *Ovularia* sp. on *Digitalis purpurea; Sphaeropsis* sp. on *Coffea arabica; Helminthosporium* sp. on *Setaria intermedia; Gonatobotryum* sp. on dead wood; *Ascochyta* sp. on *Cucurbita* sp.; *Cytospora* sp. on *Carthamus oxyacantha* and *Dothiorella* sp. on *Citrus* sp. were found to be new records for India.

(iv) *Fungal Flora of Delhi.*—Of the 130 fungal specimens collected locally during the period under report, 4 proved to be new records and are being described.

27. *HERBARIUM*:

In all, 52 mycological specimens were added to the Herbarium, bringing the total number of accessions to 27,102. Necessary nomenclatural changes were incorporated in the Herbarium sheets. Twelve specimens including 3 Type specimens were supplied to various research workers in the country and abroad. Card indices in respect of world literature on the taxonomy of Fungi and the list of specimens available in the Herbarium were being compiled.

Programme of work for 1961

(A) *Plant Pathology* :

(i) Studies on loose smut of wheat and barley, grain smut of *jowar,* bunts of wheat.

(ii) Determination of physiologic races of *Puccinia graminis tritici, P. triticina, P. glumarum, P. sorghi, P. hordei, Melampsora lini, Ustilago tritici, Tilletia foetida, T. caries, Neovossia indica* and *Colletotrichum falcatum.*

(iii) Studies on rusts of wheat, barley, sugarcane and linseed, and green-ear disease of *bajra.*

(iv) Factors affecting variation in *Colletotrichum falcatum* and recurrence of red rot epidemics; origin of new strains of *C. falcatum.*

(v) Yellow ear-rot of wheat; stalk and ear-rot of maize; red-stripe of sugarcane; citrus canker, study of bacteriophages.

(vi) Nematode diseases; micro-organism—nematode associations; 'Molya' disease of wheat and barley; "Stubby root" of sugarcane; root-knot of vegetable crops.

(vii) Screening of varieties of crop plants for their resistance to diseases, particularly rusts and smuts of wheat and barley; bunts of wheat; linseed rust; pigeon-pea wilt and grain smut of *jowar;* red rot, smut and rust of sugarcane.

(viii) Microbial antagonism and antibiotics; physiology of parasitism and fungi· factors affecting virulence of isolates of *C. falcatum.* Effect of ionizing radiations on Plant Pathogenic Fungi and Viruses.

(ix) Efficacy of different seed-dressing fungicides; laboratory, pot-culture and field-testing of proprietary fungicides and new compounds; chemotherapy.

(x) Study of ecto- and endo-phytic fungal flora of stored seeds and formulation of purity standards for freedom from diseases.

(xi) Study of the imported seed and other plant material to safeguard against the introduction of any parasitic fungi, bacteria or viruses.

(xii) Assessment of losses due to certain crop diseases with particular reference to groundnut mosaic, linseed rust, angular leaf spot of cotton, *Helminthosporium* blight of maize, etc.

(B) *Plant Viruses* :

(i) Mosaic disease of sugarcane, banana, papaya, brinjal, chilli, groundnut, plum, *Rubus ellipticus* and apple; line-pattern of plum; yellow-vein of *bhindi;* etc.

(ii) Phyllody of sesamum and other crops as also of *Brassica* spp.

(iii) Necrosis of tomato; "Foorkey" and "Chirke" diseases of large cardamom; "grassy shoot" of sugarcane; sterility disease of pigeon-pea; small-leaf disease of cotton; mango malformation; virus diseases of citrus.

(iv) Virus-vector relationships of sesamum phyllody, banana mosaic, "grassy-shoot" of sugarcane and "Foorkey" disease of large cardamom.

(v) Purification of viruses; studies of properties of purified preparations; development of new strains and cross-protection tests; serological studies.

(vi) Control of sesamum phyllody, leaf curl of tomato, papaya mosaic and "grassy-shoot" of sugarcane. Screening of varieties for their reaction to different viruses and location of sources of resistance.

(C) *Systematic Mycology* :

(i) Taxonomic study of new and unidentified collections; preparation of *exsiccatti* sets; list of fungi deposited in the Herbarium, card indices of species of fungi represented in India. Study of Fungal Flora of Delhi; taxonomic studies of Hyphomycetes, Meliolales, Erysiphales, *Alternaria, Cercospora* and *Nectria;* and maintenance of host index of fungi.

(ii) Maintenance of Indian Type Culture Collection of micro-organisms and their history sheets; study of methods for preservation of fungi, bacteria and viruses.

DIVISION OF SOIL SCIENCES AND AGRICULTURAL CHEMISTRY

(DR. R. V. TAMHANE)

A. Agricultural Chemistry

(a) *Soil Fertility* :

Manurial value of cowdung gas plant slurry.—Pot experiments were conducted to compare the manurial value of wet and dried slurry from the cowdung gas plant with Farmyard Manure. The result of the first crop of paddy has shown that the manurial value of the slurry compares favourably with that of farm-yard manure on equal nitrogen basis.

Composting with added superphosphate.—Experiments are being conducted to study if the quality and manurial value of compost is enhanced by mixing of superphosphate with the composting dung and vegetable litter. The compost so prepared is much richer in phosphorus content.

Storage of fertilizers.—Alkathene lined bags were found to be more suitable for storage of hygroscopic fertilizers than any other type of packings.

Coating the hygroscopic fertilizers with a thin layer of wax dissolved in kerosene oil reduced their loss in weight and nitrogen content with appreciable reduction in lump formation.

(b) *Microbiology* :

Studies on nitrogen transformation using stable isotopes N^{15}.—Pure cultures of Nitrosomonas were isolated from Delhi Soils for this study.

Studies on Beijerinckia Sp. in Indian Soils.—The maximum amount of sucrose was oxidised by Beijerinckia Sp. when the medium was initially at pH 5.2. The amount of gum formed increased with pH.

Bluegreen Algae.—Algae treatment gave significantly higher yield of paddy as compared to the control.

B. Soil Survey and Soil Physics

Black soils in association with other soils :

Study on the genesis of catenary soils in Durg (M.P.), reported last year, was extended to different areas of adjacent district, Raipur. The soil sequence studied at Tilda simulated the soil sequence in Durg in the morphological and other features. Similar gradation in the physical and chemical properties in gradation with the toposequence was also observed. The only deviation was that these soils were richer in iron and the soil clays were more illitic. This confirms the earlier finding that illite is the first clay mineral to be formed from the parent rock which subsequently is transformed into montmorillonite under impeded drainage condition or kaolinite under well drained condition.

X-Ray pattern of binary mixture of clay minerals :

Binary mixtures of bentonite and kaolinite, kaolinite and illite, illite and bentonite were studied for their X-ray diffraction pattern. Relative intensities of lines in the diffraction patterns of the different minerals in the pattern were measured by using calibration strips prepared with quartz. In case of bentonite mixtures, the calculated values differ by 30 per cent after correction for Lorentz polarisation factor. In case of kaolinite and illite mixtures, the results were within 5 to 10 per cent after correction.

Effect of continuous application of fertilizers and manures on soil aggregation :

Studies on water-stable aggregates in the soils from Permanent Manurial Experiment plots (New series) at Coimbatore showed that both phosphate and cattle manure treated plots had the higher contents of water stable aggregates (greater than 0.25 mm.) as compared to the control and other treatments (*e.g.* N, NK, NPK, NP, PK). Percentages of aggregates in the phosphate and cattle manure treated plots were respectively 20.4 and 22.4 as compared to 15.6 for the control. Nitrogen appeared to have deteriorating effect.

Effect of soil conditioners on soil structure :

In a highly alkaline soil (pH 9.5) collected from Delhi, germinated *guar* seed (powder) was found to be more effective in soil aggregation than the original seed without treatment. It was similar in effect to tamarind seed.

Effect of cropping practice on soil loss and run-off :

In run-off studies, the total run-off was practically similar in the plots under grass and under natural vegetation whereas soil loss was comparatively more in the grass plot than in the natural vegetation plot. Total run-off and soil loss were more from the plot under wheat-fallow rotation than those in the plot under *bajra*-fallow.

C. Physical Chemistry

Cation exchange capacity of plant roots :

The cation exchange capacity of plant roots sampled from plants at about the stage of flowering from sand culture had shown that it was independent of variations in the potassium or calcium levels or phosphate or pH levels in the nutrient solution. The maximum range of variation was from 14.82 to 13.85 m.e./100 gm. of dry matter for paddy, 14.34 to 14.64 for maize, 35.28 to 35.8 for *mung*, 50.3 to 49.3 for tobacco and 9.04 to 9.32 for wheat.

The physical chemistry of soil phosphate interaction :

The reactions between added mono-calcium phosphate of the order of about 10 kg/acre and soils from different regions were studied from the point of view of the quantitative theories of adsorption and solubility. From these it was found that in the soils from Bichpuri, Powerkhera, Coimbatore, Reura, Bhagwai and Pusa, the dominant reaction was that of adsorption of the molecules of mono-calcium phosphate as such on the soil solid phase. Hydroxyapatite was formed in the soils from Coimbatore black, Delhi and Maruteru. The phosphate ion was anionically adsorbed on the soils from Aduthurai, Karjat, Mandya, Kandaghat and also to some extent on the soils from Agartala, Burdwan and Raipur.

Thermodynamics of potassium availability in soils :

While an equilibrium potassium adsorption ratio of the soil of 0.758×10^{-2} was found to indicate potassium sufficiency in the soil for paddy, the corresponding figure for wheat seemed to be of the order of 0.308×10^{-2} which is of the order of the potassium adsorption ratio of healthy plants of these crops.

The physical chemistry of soil dispersion :

The degree of dispersion of soil is both a function of the nature and content of the soluble salts as well as the nature of its clay and that of its exchangeable cations and proportions of the exchangeable cations. The degree of dispersion of the soil clays after the soils are freed from soluble salts was found to bear a linear relation with the equilibrium sodium adsorption ratio of the soils as given below :

$$\text{Degree of dispersion} = 20 - 5 \times \text{Eq. S. A. R.}$$

This was found to hold good for normal soils of Suratgarh, Pusa, Delhi, Coimbatore, Mandya, and Guntur but not in the highly alkaline soil of Karnal and highly acid soil of Mansong.

D. Plant Chemistry

(a) *Organic Chemistry* :

Pesticides (*Botanical Origin*).—A new technique based on determining the proportions of unsaponifiables and their apparent conjugated unsaturation has been worked out. Pyrethrin I is estimated by determining the proportions and apparent conjugated unsaturation of the petrol soluble acids and Pyrethrin II by the proportions and apparent conjugated unsaturation of the petrol insoluble—water soluble acids.

(a) *Exploration of toxicity hazards in the use of modern insecticides.*—In connection with the studies on translocation of insecticides into the plants from treated soils, Bhindi (*Abelmoschus esculantus*) plants did not show any contamination in ten days with lindane at the rate of 50, 75 and 100 mg per pot.

(b) *Improvement of essential oil yielding spices of India.*—287 strains of spices seeds—*ajwain,* dill, corriander and fennel were screened. 20 out of the 96 *ajwain* strains screened had essential oil content ranging from 8 to 15% as against the usual average content of 3 to 5 per cent.

(c) *Studies in the refining of oleo-resin ex-pines longifolia for the production of quality rosin and turpentine oil.*—In order to find out possible causes for the deterioration of rosin colour, eight grades of rosin samples from Rosin Turpentine Factory, Bareilly have been analysed for acid value, unsaponifiables, ash content, saponification value, and iron content. Darker grades of rosin had high ash content and there appears to be a definite relationship between the colour and iron content of rosin.

For determining the saponification value A.S.T.M. method could not be adopted for grades of Indian Rosin as considerably coloured solutions due to the probable presence of some extraphenolic minor constituents seriously interfered with the end point. Detailed studies involving the use of potentiometric method, fluorescent indicators and thymol blue indicator showed that values obtained with thymol blue as an indicator were more or less indentical with the values obtained by other methods, the results were fairly reproducible.

(b) *Biochemistry* :

Nutritive value of wheat.—In continuation of the earlier work, the Protein Efficiency Ratio (PER) of a few more Indian wheats (NP variety) was determined. It was found to vary from 1.58 to 2.04 when fed to weanling rats at 8% protein level. The PER was greater during the first two weeks feeding than during the next two weeks' feeding. No correlation was observed between the PER and protein content of the wheats.

Chromatography of amino-acids.—R values of 19 amino acids, determined by descending paper chromatography 22 times during January to November at room temperature, showed significant variation, being low during January to April and high during August to September. Temperature and humidity appear to be responsible for the variation.

Deaminase in wheat leaves.—In the course of studies on the nitrogen metabolism, enzymes isolated from wheat leaves have been found to deaminate aspartic acid, glutamic acid, glycine, histidine and serine.

Role of copper in the nitrogen metabolism of Aspergillus niger.—Aspergillus niger was grown in a copper free sucrose—nitrate—mineral medium with graded doses (0 to 2µg Cu/50ml) of added copper. Both the mat and the liquid were analysed for amino acids, non-protein nitrogen and protein nitrogen. Under copper deficiency the synthesis of proteins was considerably retarded. Large quantities of nitrogenous compounds of non-protein nature, mostly free amino-acids, were released in the liquid medium under copper deficiency.

Metabolic activities of Azotobacter.—Azotobacter Chroococcum grown in Burk's agar medium showed no effect on alanine, glutamic acid, aspartic acid, proline and serine while threonine was oxidised as well as deaminated.

Foliar application of nutrients to crops.—Water and five concentrations of urea (1 to 4% and 6%) were sprayed on wheat crops. The total phosphorus content of wheat grains from Pusa (Bihar) and Indore varied from 0.2% to 0.3% and 0.13% to 0.18% respectively. Urea spraying appears to have depressed the phosphorus content of the grains.

E. Physics

Electron microscopic studies of algae :

The hydrolysed mucilage of *Tolypthrix tanuis*—a blue green alga and the fine structure of *Peridinium cinctern* (Muell) Ehrenberg—a dinoflagellate alga were examined under the electron microscope.

Physical properties of virus :

Cucumis virus 2C was found to have six absorption heads ranging from 2470°A to 2900°A.

F. Radio Tracer Investigations

1. *Comparative efficiency of spray and soil application of phosphatic fertilizers* :

Comparative efficiency of spray and soil application of phosphate fertilizers was studied with maize and berseem. The phosphatic fertilizers—superphosphate, monocalcium phosphate, dicalcium phosphate and ammonium phosphate, tagged with radio phosphorus were used. For soil application three doses, 80 lb., 20 lb. and 5 lb. per acre were tried. 5 lb. per acre was chosen for spray application. Total uptake, percent uptake of fertilizer phosphorus and percent utilization of applied phosphorous were measured. In maize very good response to spray application was obtained, at early stages of growth it was as efficient as 80 lb./acre dose of soil application. For spray ammonium phosphate proved to be the most efficient fertilizer. The beneficial effect of spray application on maize at early stages of growth has been shown. In berseem soil application was superior to spray at the early stages of growth.

2. *Effect of nitrogenous fertilizers on efficiency of utilization of superphosphate* :

A greenhouse experiment to study the effect was laid out. Three doses of N(O, 40 and 80 lb./acre) as urea and two doses of super (O and 40 lb./acre) were used. Plant samples were analysed for total phosphorus, total N, % uptake of fertiliser phosphorus and % utilization of the applied fertilizer. It was found that nitrogen increased the percentage uptake and utilization of the applied phosphatic fertilizer.

The additional benefit is due to the effect of nitrogen source on pH of soil and its chemical effect on the phosphate to make it more available.

G. Soil Testing

1. *Correlation of available soil-phosphorus tests and crop responses on Delhi soils* :

Of the different methods employed for extracting available phosphorus, the Olsen's method of using 0.5 N $NaHCO_3$ solution (pH 8.5) was found to give the highest correlation between soil test values and the crop responses for wheat crop on 19 Delhi Soils. The soils were of neutral to alkaline pH. The value of correlation coefficient was $r = -0.7786$, significant at 1% level. This confirms the earlier finding.

2. *Availability of phosphate as affected by changes in temperature, moisture and microbial activity in typical Indian Soils* :

(a) The available phosphorus as extracted by Olsen's method was found to increase with temperature in practically all the soil samples.

(b) The phosphate availability was less, both at saturation paste and water-logged moisture levels, as compared to air dry soils.

(c) Availability of phosphate decreased on sterilizing the soils.

3. *Effect of time on the availability of nutrients under waterlogged and arable conditions* :

(a) Liming the soil (incubated under waterlogged conditions) upto pH 7.0, increased the amount of available phosphorus.

(b) Liming the soil (incubated under sterilised waterlogged conditions) to pH 7.0 decreased the amount of available phosphorus.

Programme of work for 1961

Soil Fertility :

1. Fertilizer response in respect to yield of crops and uptake of nutrients:—
   Experiments with diammonium phosphate, dicalcium phosphate, sodium chloride along with fertilizers on wheat and paddy.
2. Soil fertility investigations under long-term manuring and crop rotation studies.
3. Use of ammonium chloride as a source of nitrogen to crops with special reference to the effect of chlorine on growth and crop composition.
4. Effect of continuous use of FYM and inorganic NP fertilizers and their combination, on the yield and chemical composition of wheat and maize using the same seeds obtained from the same plot in the previous year.
5. Development of an economic fuel gas plant for the dual purpose utilisation of cattle dung and other organic waste materials for the production of fuel gas and manure.

Soil Microbiology :

1. Studies on the relation between the efficiency of different strains of *Rhizobia* and their characteristics.

2. Studies on nitrogen transformation using stable isotope N^{15}.
3. Ecology of acid tolerant *Azotobacter.*
4. Rhizosphere effects on micro-organisms.
5. Studies on bacterisation, phosphobacterin, Azotobacterin in neutral and alkaline soils, Azotobacterin in acid soils.
6. Studies on the effect of micronutrient and vitamins on the microbiological activity.

Soil Survey and Soil Physics :

1. *Studies on Indian soils : Morphology, genesis and classification.*
2. *Mineralogical (primary & secondary) studies of soils in relation to soil development.*
3. *Studies on soil structure* :
   (a) Effect of soil conditioners on soil structure.
   (b) Water stable aggregates in Indian soils and the factors responsible for aggregate formation.
   (c) Effect of continuous application of manures and fertilizers on structure and other physical properties of soils.
4. *Studies on soil moisture* :
   (a) pF curves of Indian soils.
5. *Studies on soil conservation : Run-off and soil loss experiments*

Physical Chemistry :

1. Studies on the ionic exchanges in soils, clays and clay minerals and plant roots.
2. Electrokinetic properties of alumino-silicate precipitates, clay minerals and soils in relation to formation of clay minerals.
3. Studies on the separation and properties of clay and clay-humus complexes from soils.
4. Studies on the activities of ionic nutrients in various types of soils, clays and minerals in relation to their availability to plants.

Organic Chemistry :

1. Synthetic Pesticides—Synthesis of organic compounds with different groups, as possible insecticides; synergists for insecticides; fungicides; weedicides and formation of pesticides.
2. Pesticides of Botanical Origin—Improvement in pyrethrum and examination of indigenous plant material for pesticides.
3. Exploration of toxicity hazards in the use of modern insecticides—ICAR Scheme (Project of Entomology Division).
4. Improvement of Essential Oil Yielding Spices of India ICAR Scheme (Project of Botany Division).

5. Studies in the refining of oleoresin, with a view to produce quality turpentine oil for the production of some of the agricultural chemicals (Grant in aid from C.S.I.R.).

Biochemistry :

1. Quality of crops as influenced by manurial, cultural and management factors.
2. Nitrogen metabolism in the plant.
3. Studies on plant enzymes.
4. Available micro-nutrients in the soil.
5. Studies on plant metabolism with the use of radio-isotopes
6. Foliar application of nutrients to crops (ICAR Scheme).

Physics :

1. Study of the micro-element status of Indian Soils.
2. Qualitative identification and quantitative estimation of clay minerals in soils by X-ray diffraction technique.
3. Electron-microscopic studies.
4. Electro-physiological studies.

Soil Testing :

1. Evaluation of soil test correlation in pot and field experiments for N, P and K.
2. Fluctuation in available nutrients with season and crop.
3. Availability of nutrients in sub-soils and their evaluation in soil test-crop response correlation.
4. Evaluation of fertility on all-India soils and soil test summaries.

Radiotracer Investigations :

1. Comparative efficiency of different phosphatic fertilisers.
2. Distribution of phosphorus forms in soils.
3. Saturation degree of soils and utilisation of applied P by crops.
4. Placement studies with phosphatic fertilisers (in collaboration with Agronomy Division).

ALL INDIA SOIL AND LAND USE SURVEY

(DR. S. P. RAYCHAUDHURI)

General

The All India Soil and Land Use Survey Organisation with four regional centres at Delhi, Nagpur, Bangalore and Calcutta is mainly concerned with carrying out standard detailed soil survey in the catchment areas of six major river valley projects, namely (1) Machkund, (2) Hirakud, (3) Chambal, (4) Bhakra-Nangal, (5) Kosi and (6) Damodar totalling about 78,000 sq. miles where land improvement is projected on priority basis. In addition soil survey of non-catchment areas is also taken up at the instance of State Governments and reconnaissance soil survey is carried out under the original programme of soil correlation work.

During the period under report a total area of 9.54 lakh acres was covered by detailed and reconnaissance survey of which 2.02 lakh acres fall in the catchment areas of Mahanadi, Machkund, Sutlej (Bhakra-Nangal Project) and Chambal and 7.51 lakh acres in the non-catchment areas in the States of Punjab, Mysore, Madras, Kerala, Maharashtra, West Bengal, Tripura, Orissa, Andhra Pradesh and Uttar Pradesh. In all 46 soil survey reports covering an area of 29.69 lakh acres were drawn up during the period and sent to the concerned states for comments and execution purposes. Besides, soil classification and present land use, these reports deal with land capability classes which will be useful in formulating cropping pattern of the area as also soil conservation programme.

The Soil Survey Manual which has been published under the auspices of the organisation has been distributed to the different State Departments of Agriculture and to the different agencies carrying out soil survey work in the country for comments and for use of the field workers. The manual has been well received by all the workers in the field.

Under the scheme for Collection and Collation of Soil Survey Data in India the information on soils and crops of different States (both published and unpublished) were collected and the writing up of the final report was completed by 31st September, 1960, when the Scheme terminated.

The main Cartographic Laboratory attached to the Head Quarters continued the work on basic soil regions. The topography is being computed on the basis of the following slope ranges :—1.2, 2.4, 3.6, 4.8, 5, 5.2, 6.4, 7.6, 8.8, and 9%.

Map compilation, fair mapping, photography, plate graining, sensitizing etc. were continued.

The Soil Survey work carried out by the different Centres are detailed below:—

I. *Alluvial soil region, New Delhi*

During the period under report soil surveys were carried out in the catchment areas of the rivers Sutlej and Chambal. Soil survey for soil correlation and soil conservation purposes were also carried out in the States of Punjab and Uttar Pradesh. In all 63,018 acres were surveyed in detail the particulars of which are given below:—

Location of the surveyed area	State	Area in acres
1. *Catchment areas* :		
(i) Bhakra-Nangal Dam catchment areas (Alikhad, Sirkhad, Lunkar Khad and Gambhar Khad sub-catchments).	Himachal Pradesh & Punjab	14,995
(ii) Gandhi Sagar Dam catchment area (Awan Nadi, Khan river, and Gambhir river sub-catchments).	Madhya Pradesh .	25,653
a. *Areas other than Bhakra-Nangal and Chambal Dam catchment areas* :		
(i) District Ludhiana	Punjab . . .	800
(ii) District Jhansi	Uttar Pradesh . .	21,570

1. *Bhakra-Nangal Dam Catchment Areas* :

(a) *Alikhad and Sirkhad sub-catchments in Himachal Pradesh.*—Soil and land use survey carried out in these sub-catchments revealed the presence of a number of soil series which have mainly been differentiated on the basis of parent materials and topography. The five major soil types recognised in Alikhad sub-catchment are (i) heavy soils developed on calcareous rock fragments of limestone and quartz mixed with shales giving yellowish brown colour, (ii) colluvial soil occurring generally on the foothills of steep slopes, (iii) soils developed on pink shales with heavy texture, (iv) soils developed on gray shales heavy but non-calcareous and (v) soils developed on a mixture of shale and sandstone non-calcareous.

(b) *Lunkar-khad Sub-catchment, Punjab.*—In this sub-catchment the Punjab Government has selected 9 villages comprising an area of 17,000 acres for starting a soil conservation demonstration centre financed by the Central Soil Conservation Board. 1,632 acres of the area were traversed and mapping remained in progress. Soils are formed partly out of colluvial material and partly residual. The soils are very similar to those mapped earlier in Lunkarkhad, *viz.*, (i) Series No. 1—non-calcareous sandstone, (ii) Series No. 16—non-calcareous sandy soil formed from colluvium, (iii) Series No. 15—Soils formed out of calcareous sandstone and (iv) mixed soils, *i.e.*, sandy surface soil and heavy sub-soil.

(c) *Gambhar Khad Sub-catchment, Punjab.*—About 11 villages covering an area of 2,988 acres were surveyed. The soils mapped so far include those developed on gray, non-calcareous sandstone, gray calcareous sandstone and the mixture of sandstone and shale.

2. *Gandhi Sagar Dam catchment area* :

Detailed soil survey were taken up in three sub-catchments of Awan Nadi, Khan River and Gambhir River. Soils are predominantly black in colour developed from trap rocks. Reddish brown soils, however, occur in a few places. The topography is undulating and drainage is generally poor. About 12 profiles were examined and described.

3. *Areas other than Bhakra-Nangal Dam catchment areas* :

(a) *District Ludhiana, Punjab.*—The package programme district of Ludhiana was taken up for survey at the request of the State Government. Detailed survey of four villages covering 800 acres was completed in the area proposed to be developed as a soil conservation demonstration project. The soils of the area are sandy on the surface interspersed with salt.

(b) *Chirgaon NES Block, District Jhansi, Uttar Pradesh.*—Soil survey remained in progress in the block and 23 villages were covered during the period. Soils are similar to those reported previously and the land is very badly cut and gullied.

4. *Work done in the Chemical Laboratory and Cartography* :

433 Soil samples were analysed during the period for pH, T.S.S., $CaCO_3$ Org. carbon, N and mechanical composition. Two profile samples from Jhandota Patwar, H.P. were analysed and one showed high $CaCO_3$ content varying from 11.90% in the surface to 13.90 in the sub-surface. Texture remained loamy sand and silty loam.

Organic carbon and total nitrogen contents were 0.2 to 0.48% and 0.04 to 0.73% respectively. The Chirgaon block in U.P. has soils which are heavy, calcareous and have pH ranging between 7.5 and 9.8 Soils in Chambal Catchment are heavy and calcareous, ($CaCO_3$ ranging between 1.56 and 25.53%). The soils are deficient in organic carbon and total nitrogen contents.

Work in Cartography mainly consisted of tracing, preparation of ammonia prints or tracings to be supplied to field parties, reduction of village maps, map-compilation etc.

II. *Black Soil Region, Nagpur*

This centre covered a total area of 5,01,240 acres by detailed and reconnaissance survey of which 1,31,000 acres fall in the catchment areas in the States of Orissa and Madhya Pradesh and 3,70,240 acres in the non-catchment areas in the Yeotmal district of Maharashtra State. This centre also conducted the training of short course students in soil survey from different States.

Location of the surveyed area	State	Area in acres	Nature of survey
1. *Hirakud Dam catchment* :			
(i) Bhedan and Sapai watershed, Sambalpur District.	Orissa,	90,000	Detailed.
(ii) Mand Watershed, Raigarh,	Madhya Pradesh	16,000	,,
(iii) Mahanadi Catchment, Raipur,	Madhya Pradesh	25,000	,,
2. *Areas other than Hirakud Dam catchment* :			
Yeotmal taluk, Yeotmal District,	Maharashtra	3,70,240	Reconnaissance.

1. *Hirakud Dam catchment areas* :

(i) *Bhedan and Sapai Watershed under Mahanadi catchment, Sambalpur District, Orissa.*—The area under survey is in Jharsuguda and Laikera Police Stations spreading between Ib, Bhedan and Sapai river watersheds. Nearly 50% of the area is under forest and grassland. During the period under report 90,000 acres were covered by detailed survey.

The geology of the area is complex, quarzite, mica schists, gneissis are more commonly met with.

The forest and the grass-land which normally occupy uplands have pale yellow to brownish yellow colour and are light to medium textured soils lying over quartzite which may be unconsolidated and in turn may be on schists or gneissic parent materials.

The surface soils on uplands like *mal* show change in texture and also colour possibly due to cultivation. The colour changes from pale brown to grey brown due to various stages of decomposition of ferrugenous concretions.

Further down in wet *mal* and low lying *berna* and *bahal* lands the soils are primarily grey brown to olive brown, heavy texture with or without lime *Kankars*.

Typical soil profiles of an upland *mal* and a wet land *mal* described below :—

1. Bunded *mal* land on the border of upland forest area in village Patrapali, Jharsuguda.

0—6 inches	Yellow (10YR 7/6), loamy fine sand, single grain, dry loose, without lime and iron concretions.
6—20 inches	Yellow (10YR 7/6), fine sandy loam, weakly developed sub-angular blocky, moist, loose with few iron concretions.
20—36 inches	Light yellowish brown (10YR 6/6), sandy loam, weakly developed sub-angular blocky, moist, slightly firm, many prominent yellowish red iron specks.
36—40 inches	Reddish yellow (10YR 6/6), coarse sandy clay massive & compact, reddish dark black & brownish, prominent iron concretions.

2. A level bunded wet *mal* land in village Paikpara, Jharsuguda.

0—5 inches	Yellowish pale brown (10YR7/4), silty loam, moderately developed sub-angular blocky, dry hard, without concretions.
5—30 inches	Dark yellowish brown (10YR4/4), moist, very firm, with many iron concretions.
30—50 inches	Light olive brown (2·5Y 5/4) silty clay, massive,moist, very firm with many iron concretions.

(ii) *Mand Watershed, Raigarh, M.P.*—The area for survey is a part of the watershed of Mand river, tributory of Mahanadi. The prominent geological formation of the area is sandstone of greyish colour becoming yellowish under weathering. This is an isolated area between the hill ranges on the east and Mand river on the west having a width of about 4-6 miles. 16,000 acres of detailed survey was completed in this area.

The uplands are mainly under forest and grass lands. These are reddish light textured soils generally lying over yellowish coloured sub-soil overlying sandstone. In low-lying cultivated lands the soils are mainly grey to olive in colour, medium to heavy in texture with well developed blocky structure. These soils are quite deep with or without lime *kankars* and iron concretions are usually met with in these soils.

(iii) *Soils of Raipur* (*Arang area*), *M.P.* (*under Mahanadi catchment*).—Raipur district is a part of Mahanadi catchment and area surveyed covering 25,000 acres is an elongated piece spreading on both sides of the Raipur-Sambalpur highway with Mahanadi River on its eastern border. In this area four kinds of soils locally known as *Kanhar, Dorsa, Matasi* and *Bhata* are met with.

The survey indicating that most of the area towards Mahanadi has uniform soil which is mainly dark grey to drak brown in colour, heavy in texture, deep with or without lime concretions (*e.g., kanhar* and *Dorsa*) near the river banks, however, some light textured alluvial materials exist.

Further west-wards from Mahanadi the soil become more heterogenous. The upland soils, generally under grass and bushes are reddish yellow in colour, medium to heavy in texture and contain unconsolidated ferruginous murrum like material in the lower layers.

The remaining areas are fairly level to slightly sloping, bunded and under paddy. These cultivated soils have disturbed surface horizon due to the removal of surface layer for bunding. Mainly the soils are medium to heavy textured with heavy surface layer, very deep with or without iron concretions.

(2) *Areas other than Hirakud Dam catchment area* :

Soil Survey of Yeotmal district, Maharashtra State.—Reconnaissance soil survey of 3,70,240 acres in Yeotmal taluka of Yeotmal District, Maharashtra State was completed during the period.

Primarily these soils belong to black cotton soil. They are invariably clay loam to clay on the surface and heavier below. Excepting some river valley areas and a few localised patches in hilly areas where the soils are deep to very deep, the rest of the areas have shallow to medium deep soils occupying Yeotmal plateau and hilly areas.

The surface soils are generally full of rubbles and cobbles. Most of the cultivated areas are undulating to rolling having slope range from 3-8%. Some hilly areas having a slope of 15 to 20% are also sometime cultivated. The prominent soil colours are dark grey brown and reddish brown. Colour variation is common in hilly areas. Lime concretions are commonly found on the surface and within the profile occasionally. Shallow and medium deep soils are found on murrum. Topography is an important factor for soil differentiation in this area. Most of the reddish brown soils seem to have been formed in situ while the darker coloured soils are localised on river valley alluvium deposits.

Work carried out in the Chemical Laboratory and Cartography :

During the period 959 samples were analysed for mechanical composition, pH, conductivity, carbon, carbonate and available phosphate, nitrogen, exchangeable Ca and Mg were estimated for 540 samples. Selected soil profile samples from Guntur, Raigarh, Raipur and Andamans as also clay samples of typical areas were taken up for total fusion analysis.

In the Cartographic Laboratory 342 village maps were traced and 350 maps were reduced 138 land capability maps were also prepared during the period.

III. *Red and Laterite Soil Region I, Calcutta*

This centre covered a total area of 1,82 536 acres during the period by detailed and reconnaissance survey of which 30,520 acres fall in the catchment areas and 1,52,066

acres in non-catchment areas in the states of West Bengal, Orissa and Tripura. The details of the surveyed areas are given below :—

Location of the surveyed area	State	Area in acres	Nature of survey
1. *Machkund Dam catchment area :*			
(i) Paderu area . . .	Andhra Pradesh . .	20,740	Detailed
(ii) Araku Valley area . .	Ditto.	9,780	,,
2. *Areas other than Machkund Dam catchment area*:			
(i) Asansole sub-division .	West Bengal . .	93,095	Reconnaissance.
(ii) Kangsabati area . .	Ditto.	14,971	,,
(iii) Umerkote (Dandkaranya rehabilitation area).	Orissa	24,000	,,
(iv) Tripura	Tripura State . .	19,200	,,

(1) *Machkund Dam catchment area* :

(i) *Paderu area, Andhra Pradesh.*—The area is situated about 45 miles from Arakupalle Railway Station in Vishakhapatnam District of Andhra Pradesh. Physiographically, the area is hilly at an altitude ranging around 3,000, above M.S.L. Almost all the hills are steep to very steep, cubical or pear shaped and carry thin to dense forest but are bare at the top. Sloping uplands at the feet of the hills grade into the low valley lands. Khondalites are the main rocks of the area. Paddy and ragi are the major crops.

As revealed by a preliminary reconnaissance survey the soils fall under four broad groups, *viz.*, (1) soils of the hills and hillsides, (2) soils of sloping uplands, (3) soils of the terraced uplands and (4) soil of the low lands.

The soils of the hills and hillsides are gravelly, well-drained and severely eroded. The colluvial soils of the sloping uplands are very similar to Hollangupada series soils of the Machkund catchment in Orissa State while soils of terraced uplands correspond to the already established Developeda series soils. The soils of the lowlands are akin to Kona series soils.

(ii) *Araku Valley, Andhra Pradesh.*—It is a hilly tract at an elevation of 3,000 feet above mean sea level. The physiographic division consist of steep hills, foothill, slopes, sloping uplands and low-lying valley lands. Khondalites and charnockites are the main rocks of the region Paddy, *Samulu, niger* are the important crops.

The sloping uplands and the foothill areas have shallow to moderately deep soils which differ from the soil series establised for similar physiographic situation in the Orissa part of the Machkund basin in not having laterite murrum below. The terraced uplands have soils similar to the already established Hollangupada series. The lowland paddy fields of this area, however, have soils different from those of "Silpara series" and "Kona series" of the Orissa part of the Machkund basin. The soils of this region are characterised by a highly mottled horizon having red and dark red coloured abundantly mottled layer below the top soil.

(2) *Area other than Machkund Dam catchment area* :

(i) *Asansole sub-division, West Bengal.*—The whole sub-division has an undulating topography and forms a part of the large Gondwana group in geology. Paddy is the main crop. 93,895 acres were covered by reconnaissance survey during the period and the soils met with and mapped in the region are (1) alluvial soils consisting of Damodar alluvium and Ajoy alluvium, (2) Gondwana clay soils, (3) laterite soils and (4) lithosols.

The Damodar alluvial soils fall under three series *e.g.,* 'Shanti Series' (riverine), 'Mejiara series (upland) and Chanda series, (flatlands). The Ajoy alluvial soils are riverine and fall under Chichusbil series.

'Chalbalpur series' soils belong to the Gondwana group. Under laterite soil two series, *viz.,* Beldanga series and Indh Khara I series, have been mapped.

'Kalyaneswar series' soils of the area are lithosols.

(ii) *Midnapore District, West Bengal.*—Soil Survey in Kangsabati area was undertaken to locate new rehabilitation areas for settlement of agricultural families to be displaced due to construction of Kangsabati Dam. 14,971 acres were surveyed and the soils of the region fall under two broad physiographic groups, *viz.,* highlands and lowlands.

The highland soils are very similar to one of the two series already established for the region. They are 'Indkara series' and 'Beldanga series'. The soils of the low lands fall under either the already established Birudia series or under a new tentative soil series, *viz.,* Adalia series which is described below :—

0—7"	Very pale brown (D 10 YR7/4), Yellowish brown when moist (M 10 YR 5/4), sandy loam, massive, slightly hard and having plentiful roots.
7"—22" } 22"—38" }	Yellow (D 10 YR 7/6), brownish yellow when moist, sandy clay loam, hard sticky when wet, ferruginous concretions common; mottlings few, roots, few quartz particles present.
38"—54"	Light grey (D 10 YR 7/1), sandy clay, mottled abundantly, blocky, hard; many ferruginous concretions and stray roots.
Below 54"	Honey-comb structured murrum.

(iii) *Umerkote (Dandakaranya Project), Orissa.*—Reconnaissance soil survey of soils of the highlands around the Dandakaranya rehabilitation area was continued and an area of 24,000 acres were reconnoitered during the period. It has been found that the highland soil fall under the reddish brown laterite group. The soils are very deep and well drained.

(iv) *Soils of Tripura, Tripura State.*—Reconnaissance soil survey, as a prelude to detailed soil survey in selected centres, was taken up in Danarkhali, Gankhagur and Naransingarh areas of the State and a total area of 19,200 acres was completed during the period. It has been found that the soils of the new surveyed area generally correspond to one of the series already established for the region namely Belphang series

(forest soils), Deolia series (grey brown podsolic soils), Dhalabil series (alluvial soils) and some laterite soils.

Work done in Chemical Laboratory and Cartography :

157 Selected soil samples representative of the various mapping units were analysed for 1889 items, namely, pH, mechanical composition, Fe_2O_3 Al_2O_3, CaO, MgO, K_2O, P_2O_5, org. matter, N, exchange properties, available nutrients etc.

In cartography, 85 base maps of various survey areas were prepared and fifteen final maps were prepared covering a total area of 9,21,954 acres.

IV. *Red and Laterite Soil Region II, Bangalore*

This centre covered a total area of 2,07,135 acres of which 34,135 acres were covered by detailed survey and 1,73,000 acres by reconnaissance survey as follows :—

Location of the surveyed area	State	Area in acres	Nature of survey
(i) Ithalar village . . .	Madras . . .	6,135	Detailed
(ii) Nanjanad village, Nilgiris district	Ditto. . . .	20,000	,,
(iii) Maradi Village . . .	Kerala . . .	5,500	,,
(iv) Muhavur village . . .	Ditto. . .	2,500	,,
(v) Muvathipuzha Taluk . .	Ditto. . .	1,63,000	Reconnaissance
(vi) Puthur Taluk, South Kanara Distt.	Mysore . . .	10,000	,,

(i) *Detailed Survey of Ithalar village—Classification for Land Use—(Madras State)* :

The detailed soil survey of Ithalar village covering an area of 6,135 acres was completed. The soils of this Panchayat area have been classified under the two principal soil Series described earlier as Ootacamund Soil Series 1 and Soil Series 2. Under this Series, three soil phases have been identified and these are delineated on the Soil map. The soil phases are : (1) Ootacamund normal phase—the texture of the surface soil being usually loam or silty loam; (2) Ootacamund eroded phase—the texture being loam of sand with admixture of the weathered gneissic gravel of the B—horizon; (3) Ootacamund rough, rocky and montainous phase. As regards Ootacamund Series 2, since there is uniformity in the nature of occurrence and texture of these soils, no distinctions are made into soil types of phases.

(ii) *Detailed survey of Nanjanad Panchayat—(Madras State)* :

This panchayat belongs to Ootacamund taluk in Nigiris district. The total geographical area is 33,217 acres of which about 2000 acres are cultivated and the rest are under reserved forests. An area of about 20,000 acres in this Panchayat including the cultivated areas have been surveyed, and the balance acreage which is already under good pasture and well wooded land in comparatively inaccessible terrain, have been left out. The soils of this area are found to correspond to the Soil Series already described as Ootacamund Soil Series 1 and 2. The phases in Series 1 have been indentified and demarcated in the map. Suitable land use has been suggested for the different kinds of land and shown in the land capability classification map.

(iii) & (iv) *Detailed Survey of Maradi and Kulavur Village—Muvattupuzha taluk (Kerala)* :

The State Soil Conservation Board have selected Mulavur and Maradi villages in this taluk for execution of soil conservation work. Since the supply of a suitable soil and land capability classification map would help the execution of this work, a detailed survey of these areas was taken up. The two areas which are located about 5 miles to the west and about the same distance to the north-east of Muvattupuzha town, cover a total of nearly 8,000 acres. The soils in these areas are found to fall under Muvattupuzha Soil Series 1, 2 and Colluvium. The respective soil and land use classification maps are being finalised.

(v) *Reconnaissance survey of Muvattupuzha taluk, Ernakulam district (Kerala)*:

A reconnaissance survey of this taluk covering an area of about 1.63 lakh acres was carried out between August and November, 1960. The area lies at the foot of the high ranges and is bounded on the east in part by the Vembanad lake which connects with the Arabian Sea. The soils of this taluk are found to be capable of classification into five series, which have been tentatively named as Muvattupuzha Series 1 and 2, Alluvium, Colluvium and Peaty soils.

(vi) *Detailed Reconnaissance Survey of Puttur and Bantwal taluk (Mysore)* :

At the suggestion of the Divisional Commissioner, Mysore, a survey of the eroded areas in the above two taluks of South Canara district was taken up. From the preliminary traverse of the area, the soils are found to fall under three series, one of which is associated with laterite, the second a deep red soil derived from gneisses and the third one an alluvium.

Analytical work :

The laboratory work completed during the period included mechanical analysis of 195 samples and determination of pH, nitrogen, exchangeable calcium, total calcium, total phosphoric acid and total potash of about 150 samples besides other constituents.

Cartographic Laboratory, I.A.R.I., New Delhi

I. *Basic Soil Regions* :

A classification of land of India has been attempted to find out the regions which are uniform in the physical characteristics of land with reference to adaptability and growth of natural plants. By correlating natural vegetation with the climatic data earlier collected, the following regions have been found out :—

N. S. Quotient	*Vegetation*
75—100	Thorn forest
100—150	Thorn and Scrub forest and semidesert scrub.
150—200	Tropical dry deciduous.
200—300	Tropical entirely deciduous.
300—400	Tropical moist deciduous.
400—1000	Tropical moist deciduous
above 1000	Tropical wet ever green.

II. *Legibility determination of type faces for the reproduction of soil maps* :

Photographic copies were made of all the different type faces to study their suitability for the photography of Soil Maps. Only these faces have been selected which appeared clean—cut and solid impression of paque colour. For cultural features Century School Books Caps in point size ranging from 8 to 12 are selected. For showing topography, spartan medium Italic caps from 1 to 14 are found suitable. For reproduction of Hydrographic Features clear face Italic caps from 8 to 24 have been found satisfactory. For reproduction of Soil Data Century School Book cap and law of caps in point size 10 to 14 have been found suitable.

III. The graining Machine and the Air-Conditioning Equipment have been set up.

Soil region	State	Catchment area		Non river valley project area	Nature of survey	No. of parties	Period	Approximate area to be covered during the period. (acres)
		Catchment of	Sub-catchment of					
1	2	3	4	5	6	7	8	9
Red & Laterite soil region I, Calcutta.	Andhra Pradesh	Machkund	i. Part of Machkund. ii. Patal	..	Detailed and reconnaissance.	3	January and February.	49,000
	Do.	Do.	i. Murtalgeda. ii. Japur Bailu. iii. Machkund. iv. Tabaru Kajana. v. Siltigeda. vi. Bettagadda. vii. Rayyalgedda. viii. Kaidagedda. ix. Lasehira. x. Bongagadda. xi. Mundigedda. xii. Narangihodi. Nullah. xiii. Ondarvagu. xiv. Kabtugedda. xv. Kainigedda. xvi. Patal. xvii. Ondarigedda.	..	Do.	4	March to December (excluding the monsoon period).	245,000
	Nepal	Kosi	Khola by Khada	..	Do.	1	February to April & November to December.	40,000
	Tripura	..	..	Non-river valley project area Sadur Subdivision of the State.	Do.	1	January to May & October to December.	40,000

	Orissa and Madhya Pradesh.	..	..	Umarkote zone and Raigarh Zone.	Rapid reconnaissance.	1	Jan. to Feb.	40,000
	West Bengal	..	..	Kangsabati Project, Midnapur district.	Detailed	1	January	2,000
							TOTAL	4,16,000

N.B.—The above programme is on the basis of present strength of soil survey assistants in the centre. The work will be enhanced on the appointment of the rest of the S. S. A's the posts of which are lying vacant.

Black soil region, Nagpur.	Orissa	Mahanadi	lb watershed	..	Detailed	7 5	Jan. to March. April to June.	1,20,000
	Do.	Do.	Bhedan watershed	..	Do.	8	Sept. to Dec.	80,000
	Madhya Pradesh.	Do.	Upper Mand watershed, Korang.	..	Do.	2	Jan. to Dec.	40,000 20,000
	Do.	Do.	Mahanadi (Arang)		Do.	3 4	Jan. to June. Sept. to Dec.	1,00,000
	Do.	Do.	..	Raisen non-catchment area.	Do.	2	April to June.	20,000
	Andhra Pradesh	..	..	Guntur	Do.	2	Jan. to June.	40,000
	Maharashtra	..	..	Yeotmal	Reconnaissance.	2	June to September.	3,30,000
							TOTAL	7,50,000
Alluvial soil region, Delhi.	Punjab and Himachal Pradesh.	Sutlej (Bhakra Nangal Project.)	Sirkhad Sukarkhad Sivalikhad Gambhar Khad	..	Detailed	4	Jan. to Dec. (excluding the monsoon periods)	3,20,000
	Madhya Pradesh.	Chambal	Chambal Project area	..	Do.	4	Do.	3,20,000

Soil Region	State	Catchment area		Non-river valley area project	Nature of survey	No. of parties	Period	Approximate area to be covered during the period (acres)
		Catchment of	Sub-catchment of					
1	2	3	4	5	6	7	8	9
Alluvial soil region, Delhi	Uttar Pradesh.	..	..	Non-catchment area, Jhansi and Aligarh districts.	Detailed & reconnaissance.	2	Jan. to Dec. (excluding the monsoon periods)	1,50,000
	Punjab	..	..	Kulu Division, Ludhiana and Hoshiarpur districts.	Do.	1	Do.	1,00,000
	Rajasthan	..	..	Pali district.	Do.	1	Do.	1,00,000
							TOTAL	9,90,000
Red & Laterite soil region II, Bangalore.	Mysore	..	..	Puttur, Bantwal	Reconnaissance.	1	One year (200 working days).	1 lakh acres Reconnaissance, 2000 acres detailed.
				Hassan Taluk, Chennarayapatna and Shantigram.	Detailed.	1	Eight months (150 working days).	1 lakh acres Reconnaissance. 15000 acres detailed.
	Madras	Emerald & Avalanche rivers, Nilgiris Dist.		..	Do.	1	4 months. (50 working days).	1,000

..	..	Coimbatore taluk, Avanashi.	Reconnaiss-ance and detailed.	1	One year (200 working days).	1 lakh acres. Reconnais-sance, 20000 acres detailed.
Andhra Pradesh.		Chittoor Taluk.	Do.	1	6 months (120 working days)	1 lakh acres Reconnais-sance, 12000 acres detailed.
Kerala	Neyyar	Trivandrum District.	Do.	1	1 year (200 working days).	1 lakh acres. Reconnais-sance, 2000 acres Detailed.

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GIPN—S 1—1 IARI/61—9-2-63—650.